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UNIVERSITY OF MICHIGAN
JUL 13 1954
ENGINEERING

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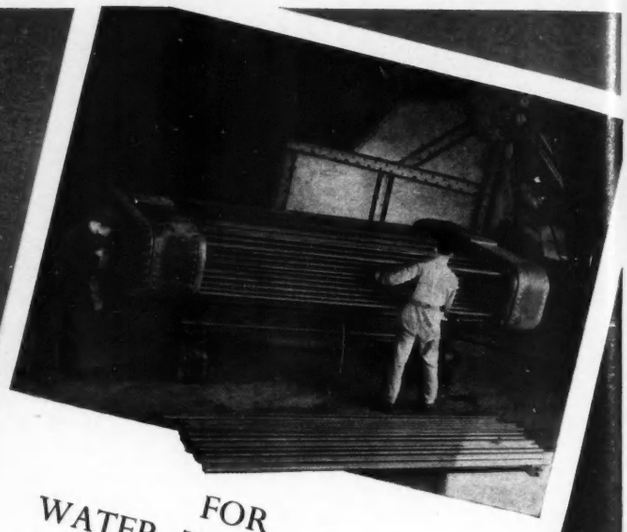
FOR AIR-COOLERS
ERW Tubes being installed in air coolers at the works of Spiro-Gills Limited, Pulborough, Sussex.



FOR WATER TUBE BOILERS
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ENGINEERING

An Illustrated Weekly Journal

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THE CONSULTING ENGINEER

As can be seen from the account we give on page 806 of this week's issue, Mr. J. R. Beard broke new ground in the presidential address he delivered to the sixth British Electrical Power Convention at Eastbourne last week. The leitmotiv of this gathering was the promotion of electrical development, both at home and overseas; and the President directed his remarks to describing the role which the consulting engineer can play in furthering that endeavour, especially in countries other than Great Britain.

Upon this he is to be congratulated; since although the British Electricity Authority has placed on record in no uncertain terms the value of utilising the experience of this branch of the profession in carrying out work connected with the design of new power stations, there remain some who regard it as the fifth wheel of the coach. This is particularly mistaken when the contribution which the consulting engineer can make to our overseas trade is examined, for not only do his fees form a valuable invisible export, but what is more important, his activities constitute a spearhead in the promotion of our engineering trade. This does not necessarily mean that the appointment of a British consulting engineer results in contracts being automatically placed with firms in this country. The first duty of a consultant is to his client and we are glad to think that this is, as it always has been, a continuing tradition.

Nevertheless, it is axiomatic that for the prosperity of the British engineering industry the export trade must be maintained; and in any efforts that are made in that direction the consulting engineer can play a valuable part in ensuring that the offers of our manufacturers receive fair consideration. He can also create an atmosphere, particularly in the underdeveloped countries, which will prove to those concerned that what is being done is as much in their interests as in our own. This is perhaps more a matter of psychology than of engineering, but even so, any endeavour which will lead overseas clients to appreciate the professional and ethical outlook of the British consulting engineer will be well repaid, both in good will and in more material directions.

Unfortunately, progress along these lines is hampered by the requirements of professional practice in this country: that consulting engineers shall not advertise or solicit work. Although it would be undesirable that this practice should be abandoned there is a growing appreciation of the fact that its strict interpretation will make it extremely likely that British consulting engineers will receive many appointments in some countries overseas, where greater freedom is permitted. In fact, so difficult is the position that the Board of Trade is continuously pressing the matter on the Association of Consulting Engineers. It is, of course, advisable, as Mr. Beard pointed out, that any move towards relaxation should be made with caution. At the same time, the discussion of the problem should not be delayed; and we shall be interested to learn what results emerge from it.

The consulting engineer is also hampered by a practice, which has developed in the United States and other parts of the world, of firms offering to design and carry through a project to completion at a sum which covers consulting services, manufacture and erection. At first sight, such an arrangement certainly offers attractions to the lay client, especially in the underdeveloped countries. Further consideration will, however, show that it is not always in the best interests of the client from either the financial or the technical points of view. For this reason, and again at the urgent request of the Board of Trade, consideration is being given to arrangements whereby British consulting engineers can assist groups of British contractors by preparing designs for a comprehensive tender and subsequently carrying out on behalf of the group the supervisory functions connected with manufacture and erection. In view of present conditions, such an arrangement has much to recommend it, with the proviso that the client shall, if he wishes, be free to appoint his own consulting engineer after the comprehensive offer has been accepted.

It was a deserved tribute to the integrity and value of British consulting engineers that so many of the speakers on Sir George Nelson's paper, "Electrical Engineering in World Trade," which also formed part of the proceedings of the Convention, should, while paying tribute to the advantages of the "all-in" bid, have also stressed the value of independent arbitrament. Sir Vincent de Ferranti, for instance, in recalling that his father had been both consulting engineer and contractor for the historic Deptford station, deplored that practice on the grounds that consulting engineers had a much wider field of experience on which to draw and must always in the end be able to give the client a better job. Without further evidence to the contrary, it may be said that that is a fair statement of the position; but it is satisfactory that the whole question is to be reconsidered.

Weekly Survey

COMMONWEALTH ENGINEERING INSTITUTIONS

Senior officers of engineering institutions of the Commonwealth met in London from May 24 to June 4. A similar Conference of Engineering Institutions of the British Commonwealth, as it is called, was last held in Johannesburg in 1950, and the next is to take place in Australia in 1958, at the invitation of the Institution of Engineers, Australia, supported by the New Zealand Institution of Engineers. At the conclusion of the recent London meeting, at which the Institution of Civil Engineers, the Institution of Mechanical Engineers and the Institution of Electrical Engineers were the hosts, a joint statement was issued.

In the course of ten business sessions, the statement explains, the Conference discussed a number of matters of interest to its consituent institutions, their members, and the public whom they serve. "These ranged from such matters as the proper conservation of natural resources . . . to more detailed questions touching the education and training of professional engineers, the assistance which the engineering profession can give to the provision of adequate numbers of fully competent engineering technicians, and measures to secure the most effective interchange of lecturers and speakers on engineering subjects. Recommendations to the councils of the constituent institutions were drawn up and when these have been approved by the councils they will be published in the journals of the institutions.

"The delegates also participated in a number of social engagements designed to bring them into contact with representative British engineers, and to let them see examples of British engineering in the fields of education, industry and research. These included a reception by Her Majesty's Government, and visits to Hampton Court, Oxford, Cambridge, Stratford-on-Avon, and the Cotswolds, in the course of which engineering establishments as well as places of scenic or historic interest were visited. At a dinner to mark the end of the Conference the visiting delegates expressed their appreciation of its work and their conviction that the decisions freely arrived at would be of the greatest benefit to the profession of engineering and thus to the public at large."

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DORMAN LONG: THIRD STAGE OF DEVELOPMENT PROGRAMME

The third and final stage of Dorman Long's £50 million post-war development programme is now beginning. It was originally expected that the entire plan would be realised by about the end of 1957 and at the moment it does not look as though there will be any very serious delay. The programme envisaged an increase in ingot production from 1·85 million tons to 2·3 million tons per annum and a corresponding increase in rolled steel output from 1·5 million tons to 1·9 million tons per annum. The first two stages of the programme covered mainly the provision of modern ore-unloading equipment, ore preparation and sinter plant at the Cleveland works, and an open-hearth smelting shop at Lackenby. These developments cost about £14 million leaving an investment of about £36 million to be carried out at the third stage, which is now likely to be completed in 1958.

Stage 3 allows for the installation at Cleveland of two new blast furnaces, a coke-oven plant, a new blooming mill, a new medium-section mill and a new high-capacity rod and bar mill. When completed the entire investment of £50 million will have consisted of £21·5 million for the beam mill and other rolling mills, £11·5 million on iron production, £8·5 million on coke production and £8·5 million on new steel capacity. The universal beam mill for structural sections will be the only one of its particular kind in Western Europe making both H- and I-sections in the one mill. About 6 million dols. has been spent on American equipment and it is expected that the new mill will bring a saving in steel construction of between 5 and 20 per cent., and a saving to constructors of about 13½ per cent. on materials at present used. By rolling to American standard sizes Dorman Long will also improve their competitive power in seeking American orders.

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COLOUR TELEVISION

Television is a subject which provides the acutest controversy and colour is only one of its aspects about which it is difficult to form an objective judgment. British manufacturers have been criticised for slow development progress, and the B.B.C. for lack of enterprise in introducing a service. In contrast, colour broadcasting has already been introduced into the United States where manufacturers have talked optimistically of selling 100,000 colour television sets in 1954. Demand has, however, proved to be disappointing so far; up to the end of April only about thirty sets had been sold. The high price of the receiving sets alone (1,000 dols.) precludes the possibility of heavy sales and manufacturers also believe that the 15-in. colour picture has proved to be too small for the American public who compare it unfavourably with 21-in. black-and-white pictures. They are therefore hopeful that sales will improve when 19-in. colour tubes are offered later in the year.

Even so, it is clear that colour television is unlikely to make as rapid progress in the United States as had been expected. A leading executive in the United States television industry recently went so far as to say that the television industry now found itself in an untenable position through having launched a colour service without the technological ability to deliver it within the standards and economic limits acceptable to the public.

The more cautious British approach may prove to be the wisest. British manufacturers, with comparatively little publicity, have gone a long way with the development of colour television. Pye, Limited, first demonstrated it as long ago as 1949 and televised the Coronation in colour for the benefit of a children's hospital. Marconi's Wireless Telegraph Company will also be able to provide colour equipment when it is required in the United Kingdom. They have a cross-licensing agreement with the Radio Corporation of America, and a few weeks ago demonstrated a colour system basically the same as that of the RCA but modified somewhat by Marconi's and adapted to British standards. Another British radio-manufacturing company, Thorn Electrical Industries, have now announced that they are to co-operate with a United States company in the development of colour television. Jointly with Sylvania Electric Products, they are to form a new company, Sylvania-Thorn Colour Laboratories. Work is to begin at once in premises on the outskirts of London.

It is unlikely that colour television services will be introduced for a long time by the B.B.C., who have preferred to devote their capital resources to extending the coverage of black-and-white television and improving the quality of sound broadcasting. This is no doubt justified, but it is to be hoped that they will back the enterprise of the manufacturers by introducing a colour service as soon as it becomes practicable.

An idea of the quantity of research work that has been done on colour television can be gained from the comprehensive booklet, *A Bibliography of Colour Television*, originally compiled by Ultra Electric, Limited, and now published in an amplified form by The Television Society, 164 Shaftesbury-avenue, London, W.C.2; copies (price 2*s*., post free) can be obtained from the secretary of the Society. The *Bibliography* is divided into two parts, "Optical" and "Electrical," which together refer to nearly 400 items in chronological order of publication; an author index is also given.

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TRENDS IN MOTOR VEHICLES

The intense competitive struggle in the United States car market has led to substantial gains by the General Motors Corporation and the Ford Motor Company at the expense of the Chrysler Corporation and other companies. The G.M.-Ford share has risen from 66·8 per cent. of total car sales in January to April, 1953, to 82·5 per cent. in the corresponding period in 1954. Chrysler's share had fallen from 21·4 to 12·9 per cent. and that of other "independent" companies from 11·8 per cent. to 4·6 per cent. This trend, which may be arrested by anti-truts action on the part of the United States Government, has its roots in important changes in production techniques. The competitive war between G.M. and Ford has so far consisted of price cuts, some of which, at any rate, reflect reductions in production costs. These have to be achieved in the face of a five cent an hour "annual improvement" provision in the manufacturers' contracts with the United Automobile Workers' Union. The effort to reduce costs has led to the use of bigger and faster machine tools and to rapid advances in the automatic control and operation of plant and machinery. This has put a premium on standardisation and long runs of production, to the marked advantage of the companies with the largest output. To secure economies in the production of components and to permit closer planning of production, manufacturers have tended to make more components themselves. The very high cost of these developments, higher than at any time since the war, tends to favour the giants. General Motors, for example, who spent 350 million dols. on special tools, dies, jigs and fixtures for the production of their 1954 models, plan to spend 1,000 million dols. during the next two years.

Similar trends can be observed in the British motor industry, though at a much earlier stage. There has been a marked growth in the proportion of total output accounted for by the British subsidiaries of Ford and G.M., the Ford Motor Company, Limited, and Vauxhall Motors, Limited. Their share of total motor-vehicle production by the six leading companies, which was 36 per cent. in 1938, rose from about 35 per cent. during 1952 to 41 per cent. during the first quarter of 1954. The 1954 figures did not include any Ford "Anglia" cars which were not then in production, and a further increase in the proportion accounted for by these two companies is expected during the second half of this year.

There has been a marked growth in the concentration of British motor-vehicle production in the past few years. The principal steps were the merger of the Austin Motor Company, Limited, and the Nuffield group, and their subsequent acquisition of Fisher and Ludlow, Limited, the merger of the Standard Motor Company, Limited,

and the Rover Company, Limited, Ford's acquisition of Briggs Motor Bodies, Limited, and a major extension of production facilities at Vauxhall's Luton plant. The trend is likely to continue, particularly as the markets become more competitive and labour costs increase.

Mr. R. Gresham Cooke, director of the Society of Motor Manufacturers and Traders, recently defined the industry's major problem as " that of holding and reducing its cost of production." The most important developments at present under way are the erection of Vauxhall's new plant at St. Albans which will make possible a large increase in that company's output, and the integration of manufacturing facilities in the British Motors Corporation group of factories. Unfortunately for the industry, the Board of Trade, the Ministry of Town and Country Planning and other Government departments have prevented the building up of large fully-integrated units, even where the companies concerned owned land earmarked for the purpose. Striking examples of this are Vauxhall at Luton and Ford at Dagenham. There are doubtless good reasons for such a policy, both on social and aesthetic grounds, but it cannot be in the best interest of low-cost production.

The industry's excellent performance so far this year should not blind its members to the need for more standardisation and a greater concentration of output, particularly in the manufacture of components.

* * *

KNITTING-MACHINERY PROSPECTS

The acquisition of Mellor Bromley and Company, Limited, by The Bentley Engineering Company for over £2 million – some £300,000 more than the market value of the shares when the offer was made last February – is the latest of a number of moves which have suggested that the prospects for knitting-machinery manufacture are bright and have been underestimated. Little support for this view is to be found, however, in the latest figures of output or in the reported state of order books. In the late 1940's the industry could deliver very few of its products in under five years, in 1953 very few delivery delays were greater than one year, now there are signs that orders on hand are inadequate to maintain production at full capacity. Deliveries of hosiery, knitting and lace machinery in the first quarter of this year totalled £1·67 million, 15 per cent. lower than in the first quarter of 1953; deliveries for export, which accounted for more than half the total, had fallen by 27 per cent. over the same period. The knitting-machinery industry appears to be following the same path, at some two years' interval, as the makers of cotton-spinning machinery and if this is so the makers of knitting machinery will have to face considerable difficulties.

Foreign competition is particularly keen from Germany, the United States and Switzerland who before the war accounted for the bulk of world trade in hosiery machinery. In 1935 the output of the British industry averaged about £310,000 a quarter, estimated to represent less than half the 1953 volume. Considerable expansion took place after the war to meet needs at home and overseas which the United States and Germany could no longer supply. Unfortunately, British makers do not appear to have made the considerable progress required to establish a technological lead over their foreign competitors. The recovery of the German industry, at a time when world demand for knitting machines appears to be falling, has hit them hard.

Mr. P. A. Bentley, the Group's chairman, pointed out in his statement to a shareholder at the Annual General Meeting on June 11, that the acquisition of the Mellor Bromley group should make possible some reductions in production costs – presumably through the simplification of the two companies' ranges of products and the introduction of standards – as well as improvements in sales effectiveness in the export markets, where " much good could be done by joint representation ". Mr. Bentley drew the shareholders' attention to the diverse range of Mellor Bromley products, which include air-conditioning plant, dyeing and finishing machinery, laundry machinery, mining machinery and quarry plant: " These activities have the effect of broadening the trading of the whole group and to some extent sheltering us from the effect of any marked recession in the hosiery industry." Basically, however, the Bentley Engineering group depend on the successful selling of a wide range of hosiery and knitting machines in world markets, which, during the next two to three years, are likely to be a great deal more difficult than they have been since the war.

* * *

HELICOPTER PROGRESS

No one can criticise the British aircraft industry for lack of enterprise, but in helicopter development they have hitherto lagged perceptibly behind some of their competitors. Fortunately, the gap is being narrowed. The Minister of Supply, Mr. Duncan Sandys, recently announced that Government expenditure on research and development work for helicopters in 1953-54 would be £1·3 million compared with £573,000 in 1952-53 and that in 1954 it was likely to increase to more than £2·5 million. Recent large orders show that the military authorities as well as the commercial operators appreciate the importance of the role of the helicopter in air transport. At present, the Royal Air Force have only about 20, although some are also in service with the Navy and the Army. A further 50 are due to be delivered over the next twelve months, and altogether 200 helicopters of different types are now on order for the British Armed Services.

British European Airways can take the credit of having inaugurated the world's first regular passenger helicopter service – between Liverpool and Cardiff on June 1, 1950, but hitherto they have been able to operate only single-engined three- or four-seater machines, which are too small to be economic at acceptable fares. The monthly return fare of £2 10*s*. for the service opened last week between London Airport and Eastleigh Airport, Southampton, is probably too high to create a large demand, and is certainly too low to be economic for the Bristol 171, which, in addition to baggage, will only be able to carry three passengers. The main value of the new service will be in the operating experience which it provides.

The profitability of helicopter services will increase when B.E.A. put the Westland Sikorsky S55, 10 to 12-seater, in operation. They expect to take delivery of the first of two on order in the autumn, so that they should be available for the experimental passenger service between London Airport and the South Bank, which, following the recent relaxation of flying regulations, B.E.A. propose to start next March. Something much larger is, however, desirable for commercial operations, and unfortunately, it will be some years before helicopters to the " BEA-line 'bus " specification (40 to 60 seaters) of which the Bristol 181 and the Fairey Rotodyne are examples, can go into service. Mr. Sandys said of the Rotodyne a few weeks ago that it raised a number of problems, such as how to reduce noise to make it acceptable for inter-city services, and that its development, which represented an entirely novel idea, had a long way to go.

Some improved British helicopters will of course be available before the BEA-line 'buses – for example, the Bristol 173, the mark 3 version of which will be capable of carrying 18 passengers – but production models of this machine are still some way off. In the United States on the other hand, at least two large helicopters are expected to be in passenger service in 1957 or shortly afterwards. These are the twin-rotor Piasecki H-16 (50 passengers) and the single-rotor Sikorsky S56 of slightly smaller capacity. In the United States there are at present about 3,000 helicopters in military service alone and many valuable hours of operational service were put in during the war. Despite the increased outlay on development the United Kingdom has thus a long way to go to catch up with the American lead in helicopters.

* * *

FUEL AND POWER STATISTICS

The *Ministry of Fuel and Power Statistical Digest* for 1953, which was published by H.M. Stationery Office on Tuesday, June 22, at the price of £1 1*s*., contains, in addition to other information, the results in tabular form of a survey of steam and power usage in industry, which was made during the past year. The principal object of this survey is to provide data from which estimates can be made of the possibilities of extending the employment of back-pressure or pass-out engines and turbines for the generation of power, thus promoting the efficiency of fuel utilisation.

For this purpose a *questionnaire* was sent to industrial, commercial and other establishments believed to be using more than 2,000 tons of fuel a year in the form of coal, coke or oil (oil being assumed to be equivalent to twice its weight in coal). There are about 4,600 such undertakings with a total fuel consumption of 63 million tons per annum and the *questionnaire* was completed by about 84 per cent. of them.

The tables show the distribution by industries and size of the annual fuel consumption of the establishments that completed the *questionnaire*, as well as the consumption by types of plants and for various purposes, their steam production and evaporative factors. Other information, again in tabular form, shows the annual steam production of establishments by industries, the weekly use of live steam in summer and winter, and the distribution of steam boilers in use according to type, age, size and working pressure. These latter figures indicate that 6,201 Lancashire boilers account for over half of the total of 11,158. Of these, 4,030 are over 30 years old and 5,608 have outputs of 5,000 lb. or less of steam per hour. There are 2,012 water-tube boilers, of which 686 fall into the same output category. As regards prime movers, 5,532 (of which 2,430 are back-pressure turbines, and 398 pass-out turbines, 798 either condensing engines or turbines or steam engines exhausting to the atmosphere and 499 Diesel engines) are installed in 2,005 establishments, their total capacity being 3,247 MW, of which 2,448 MW were used for generating electricity. Of these, a considerable proportion of the back-pressure and " other steam engines and turbines " are over 40 years old, while most of the pass-out turbines are of much more recent date.

It remains to be seen what use can or will be made of this mass of statistical information, although we understand that it has already led to the question of the fuel economy of their plant being examined by certain firms.

I.MECH.E. SUMMER MEETING IN THE NETHERLANDS

Without doubt the first summer meeting that the Institution of Mechanical Engineers have held abroad since 1931 was a great success. Those who already knew the Netherlands did not need to be told of the special warmth of feeling which unites the Dutch and the British, but for those whose preconceived notion was of a country too flat to be interesting and a people too occupied with fighting water to be gay, the visit proved to be a revelation.

A book would be needed to do justice to the Netherlands – a nation which is great in the way that only a small nation can be great. For an engineer, part of its greatness may be attributed to its remarkable technological and industrial progress in spite of being a late starter in the Industrial Revolution. This growth was reviewed in a very fine lecture given by Mr. F. Q. den Hollander, President of the Netherlands Railways, at the opening session on Tuesday, June 15.

The President, Dr. R. W. Bailey, F.R.S., and members of Council and of the Institution, with their ladies, were welcomed at the opening session held at the Hotel Kurhaus, Scheveningen, by the Burgomaster of The Hague, Mr. F. M. A. Schokking, who was accompanied by the President of the Koninklijk Instituut van Ingenieurs, Dr. J. A. Ringers, C.B.E. After Mr. den Hollander had delivered his address, a vote of thanks was proposed by Dr. H. J. Gough, F.R.S., Past-President. Dr. Gough remarked on the novel and masterly treatment of the subject – "The Industrial Netherlands" – and paid a tribute to the Dutch people for their pertinacity and skill. Mr. R. A. Riddles, C.B.E., who seconded the vote of thanks, said that Mr. den Hollander had given no hint in his address of the part he himself had played. Mr. den Hollander was a great industrialist.

A Reception was held on Tuesday evening by invitation of the Minister of Education, Arts and Sciences, Mr. J. M. L. Th. Cals, and the Municipal Board of The Hague, in the Old Town Hall of the city. The following morning the Automobile Division of the Institution held a meeting in the Delft Technological University, with the Chairman of the Division, Professor S. J. Davies, presiding. Professor J. J. Broeze, Director of the Royal Dutch/Shell Laboratory at Delft, read a paper on "Automobiles and Petroleum: Past, Present and Future," and it was announced that Mr. J. H. Pitchford would be the next Chairman of the Division. After the lecture a tour was made of the engineering workshops and laboratories.

The Institution Dinner was held at the Hotel Kurhans on Wednesday evening, with Dr. R. W. Bailey in the chair. Proposing the toast of "The Engineering Profession and Industries of the Netherlands," Mr. A. C. Hartley, C.B.E., past-President, recalled some of the many influences and experiences shared by the Dutch and British people: both had the great privilege of having a Queen, with a husband at her side, taking an interest in the welfare of all classes; both were concerned, in questions of productivity, with quality rather than quantity; and they had both suffered the devastation of the North Sea floods last year. The defences against the sea, he said, must be the work of the two countries working together. Research on the subject must be done jointly. The response to the toast was by Dr. Ringers and Mr. den Hollander, and the toast of "The Guests," was proposed by Mr. T. A. Crowe, M.Sc., vice-president, and replied to by Mr. J. W. Ernste, general manager of the B.P.M. Refinery at Pernis, Rotterdam. Visits were paid during the summer meeting to numerous industrial establishments and places of interest in the Netherlands.

* * *

BIRMINGHAM EXCHANGE ENGINEERING CENTRE

Permanent Exhibition for British Engineering Industry

The Birmingham Exchange Engineering Centre, in Stephenson-place, Birmingham, 2, which was officially opened by Lord Bennett of Edgbaston, O.B.E., LL.D., J.P., on June 17, has a three-fold purpose. It is designed as a non-profit distributing organisation to provide a means of showing the foreign engineer and buyer what the British engineering industry has to offer; to act as a rendezvous for British engineers; and to give the young engineering student facilities for examining a cross-section of the products of the industry. The Centre is therefore equipped not only with a very large range of exhibition stands, but also with a library and information bureau, lecture rooms with film-projection facilities and private offices with secretarial and telephone services for visiting executives. There is also a separate exhibition room, 33 ft. by 22 ft., with single- and three-phase electric supply and lifting tackle, which is specially designed for private short-term exhibitions. The Centre will be open throughout the year from 9 a.m. to 5 p.m. on weekdays, and from 9 a.m. to noon on Saturdays. Admission is free. The main entrance to the Centre, which is conveniently situated near to the two main line railway stations and the principal hotels in the City, incorporates a display window in which a single item, to be changed from time to time, is exhibited. At present, this window contains a sectioned Armstrong Siddeley "Adder" turbo-jet engine.

NOVEL INTERNAL FEATURES

The exhibits are arranged on the ground floor and on a gallery. There are 200 exhibitors, from all parts of the country, displaying a very wide range of products of the light and heavy mechanical and electrical engineering industries. The exhibits will be changed as new products become available, it being the intention of the organisers that the Centre shall at all times present a thoroughly up-to-date picture of British industry. Past experience of exhibitions on more than one floor have shown that there was a certain amount of reluctance on the part of visitors to ascend the steps leading to the upper floors, and the architect responsible for the layout of the Centre, Mr. D. Rosslyn Harper, A.R.I.B.A., has therefore introduced a gently-sloping ramp, which leads directly from the entrance to the gallery. The visitor, on entering the Centre, sees a row of flush-fitting lights in the floor, which curve away to the left; by following these lights he is led automatically to the ramp, and so to the gallery.

Exhibition stands are arranged on each side of the ramp, and are continued right round the gallery, which is widened in one part to include a number of island sites for stands. The gallery terminates in a small lounge and coffee room, at the entrance to which are vertical racks containing the current issues of about 200 technical journals. At the end of the gallery, near to the coffee room, there is a spiral staircase, 8 ft. in diameter, which leads down to the ground floor, where there are further exhibition stands. All the stands, both on the gallery and on the ground floor, are of uniform pattern, designed to present a pleasing appearance, and not to distract the attention from the exhibits.

At the foot of the spiral staircase is the information bureau, which will be staffed at all times when the Centre is open. No literature is available on any of the stands, but the information bureau is provided with adequate supplies of literature for each firm exhibiting. In addition to providing printed matter and information on request, the bureau will maintain a file for every exhibitor in which details of all inquiries will be entered. It is intended to compile, in the information bureau, a capacity and agents' register.

The basement of the Centre contains an air-conditioned lecture hall, which has an acoustic-tiled false ceiling, and will be available for the use of technical societies. This lecture hall can be partitioned off during the day into two offices for the use of visiting executives. Telephone facilities are provided in an adjoining room, which is also equipped with writing desks. A typist will be available daily to deal with correspondence.

* * *

EXTENSION OF HIGHLAND GRID

Shin – Caithness Transmission Lines

The Right Honourable James Stuart, M.P., Secretary of State for Scotland, has confirmed a scheme prepared by the North of Scotland Hydro-Electric Board which will connect the five generating stations to be built under the Board's Loch Shin Project in Sutherland and will also extend the Board's Highland Grid. The purpose of the scheme is to enable supplies of electricity from the Board's hydro-electric stations to be sent to Caithness at an estimated cost of £1,702,000.

Overhead transmission lines will run from the main generating station of the Loch Shin Scheme at Inveran to the generating station at Ben Hee. Overhead and underground lines will connect this line with the other generating stations at Lairg and Cassley and the Garvault generating station will be connected to the station at Ben Hee. Transforming stations will be built at Inveran, Lairg, Cassley and Ben Hee. The extension of the Board's Highland Grid will be from the main generating station at Inveran to Mybster, south of Halkirk in Caithness, where a transforming station will be erected.

A White Paper on the scheme has been published and is available from H.M. Stationery Office, 13A Castle-street, Edinburgh, or through any bookseller.

* * *

COURSE ON INSTRUMENT MAKING

A five-year part-time course on instrument making is being prepared by the City and Guilds of London Institute as a means of supplementing the normal industrial training of apprentices to the instrument-making and light precision-engineering trades.

The course will commence with the coming session and is being arranged in two parts: an intermediate stage planned to cover a period of three years and a final stage designed to be completed in two years.

Examinations at both intermediate and final levels will take place annually; the first intermediate examination to be held in 1955 and the first final examination in 1956. Pamphlets containing full particulars of the course may be obtained, price 6*d.*, from the City and Guilds of London Institute, Department of Technology, 31 Brechin-place, London, S.W.7.

Letters to the Editor

BEAUCHAMP TOWER

Early Experiments in Lubrication

SIR, A few years ago I tried with little or no success to collect information on Beauchamp Tower, who made the first serious experiments in lubrication. He was not sufficiently prominent during his life to have merited much biographical material and there does not seem to be any of his immediate family surviving. His contemporaries would have to be very old to be alive and the societies to which he belonged have very little about him.

Since Tower's work led to the theory of lubrication there is a belated interest in him and particularly in the circumstances of his doing the work on the railroad-car journals for the Institution of Mechanical Engineers. In particular it would, I think, be of great interest if a picture of Tower could be found.

I would be grateful to any of your readers who can help me with information. There is still, of course, a chance of finding someone who knew Tower, but the chance is getting smaller every year.

Yours faithfully,
FRANK R. ARCHIBALD.

18, Irving-street,
Melrose,
Mass., U.S.A.
June 4, 1954.

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DYNAMICAL ANALOGIES

Vibrating Beam and Electric Transmission Line

SIR, In belated comment on the letter from your correspondent, Mr. W. M. Skenfield (ENGINEERING, January 15, page 67), I wish to to point out that his intuition has, indeed, led him astray and that the electrical transmission line is not, in fact, analogous to a cantilever or any other beam.

This discrepancy arises from the fact (see Fig. 1) that in the mechanical system, the amplitude of y_n is dependent upon both the deflection and the slope of y_r. The electrical equivalent of such a system would indeed be "something more complex than the simple transmission line."

In order to show just how complex the analogous circuit may be, consider the case of the cantilever, using the velocity/voltage analogue. It can be shown that the electrical analogue is something of the form shown in Fig. 2. The value of n is determined by the ratio of slope to deflection and is therefore applicable, when suitably modified, to other types of beams.

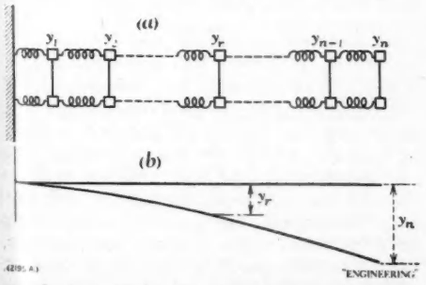

Fig. 1 Showing (a) the mechanical representation of a cantilever; and (b) the deflection diagram.

Incidentally, the use of the more tractable form of electrical-mechanical analogue (i.e., voltage = velocity) does not appear to be fully appreciated by mechanical engineers, and it is hoped that in the near future a paper will be published showing some possible uses of this method.

Yours faithfully,
W. A. KELLY.

20, Davenham-close,
Malvern,
Worcestershire.
June 3, 1954.

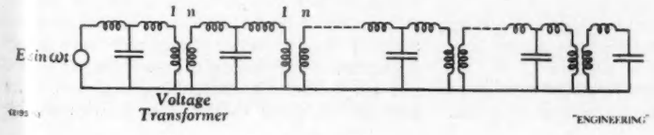

Fig. 2 Electrical analogue of a cantilever.

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RIGID FRAME FORMULAS

Solving Highly Redundant Frames

SIR, I cannot agree with your remarks about the labour of solving indeterminate cases involving the combination of indeterminate cases. In fact, I think you have missed the point completely.

It will be recalled that in your review of the English translation of Professor Kleinlogel's *Rigid Frame Formulas*, in ENGINEERING for March 26 (page 393), you referred to my Foreword to the book, in which I said that "the rigid frames, themselves statically indeterminate, can be used as units in adopting a 'primary structure' dealing with cases of more highly indeterminate frames, and so bring such structures within the range of easy computation by means of the Maxwell-Mohr work equation or, if one prefers, the slope-deflection equations. This extends considerably the field of practical application in the design of such structures and makes available an accurate and rapid method of analysis of structures which could heretofore be handled only by approximate methods or by lengthy numerical computations." Your comment on this was that "since the resolution of a framework with six redundancies entails eight or ten times the labour of unravelling one with only three, the work of combining two third-order solutions may be expected to be six or eight times that of solving one from the basic elastic equations."

If we select, for example, two rectangular frames, each indeterminate to the third degree, connected at the top by a horizontal beam with rigid connections to them, we have a structure indeterminate to the ninth degree. If the Maxwell-Mohr work equation method of setting up the elastic equations is to be used, then by adopting a primary structure consisting of two redundant frames the bending moment diagrams for which can be quickly worked out from the Kleinlogel tables, only three elastic equations are required. Thus, instead of computing 45 coefficients and nine loading terms for a 9th degree redundant structure one need compute only six coefficients and three loading terms. The Müller-Breslau tables for $\int \overline{M}M\,dx$ are very useful for this purpose if the values of the moments of inertia are constant for each member.

In order to present the matter in more detail I am sending you a reprint from the *Canadian Journal of Research* (December, 1948) of my paper "On the Extended Use of Kleinlogel's Rahmenformeln." This paper is not widely known; I have had requests for it from Canada, the United States, and Mexico but not from Britain. Perhaps some of your readers would be interested in it.

Yours faithfully,
I. F. MORRISON,
Professor of Applied Mechanics.

University of Alberta,
Edmonton,
Alberta,
Canada.
April 28, 1954.

[Our comment was based on the usual assumption that, in general, the labour of solving redundant structures increases in a ratio rather higher than the cube of the ratio of numbers of redundancies. Obviously, there are exceptions, as in elementary moment distribution with no side sway, when consecutive equations are so weakly coupled that the labour of solution is little more than directly proportional to the number of redundancies. To illustrate his argument, Professor Morrison has used a simple example in which three equations are required to find the connecting reactions, but if he had set his frames one above the other he would have had two connecting members and six elastic equations to solve for a "9th degree redundant structure," using the Maxwell-Mohr method in conjunction with the Kleinlogel formulas.—ED., E.]

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PERSONAL

SIR HAROLD ROXBEE COX, Ph.D., D.I.C., B.Sc., M.I.Mech.E., F.R.Ae.S., who has been chief scientist to the Ministry of Fuel and Power since 1948, is resigning from the public service on June 30, in order to accept appointments in industry.

CAPTAIN (E) H. J. B. GRYLLS, A.D.C., R.N., has been promoted to Rear-Admiral (E) and appointed engineer manager at Devonport Dockyard, in succession to Engineer Rear-Admiral C. R. P. Bennett, C.B.E., who is retiring.

MR. J. C. MORRIS, B.Sc., A.M.I.C.E., F.R.San.I., borough engineer and surveyor of Willesden, London, has been appointed chairman of the council of the Royal Sanitary Institute, 90 Buckingham Palace-road, London, S.W.1. He will take over his new duties in October next.

MR. H. C. ADAMS, M.C., M.A., M.I.C.E., has been appointed an assistant chief engineer at the headquarters of the Ministry of Transport and Civil Aviation, in succession to Mr. C. S. Chettoe, B.Sc. (Eng.), M.I.C.E., who is retiring on September 16, 1954.

MR. LEWIS BURN, M.I.Mech.E., M.I.Mar.E., M.S.A.E., has joined the staff of Armstrong Whitworth (Metal Industries) Ltd., Close Works, Gateshead-upon-Tyne, 8, as consultant engineer. His work for the company will be concerned partly with the further development of the "Burn Gear" and the Beier infinitely-variable gear.

MR. R. E. BUELL has been appointed controller of the technical division of the Regent Oil Co., Ltd., 117 Park-street, London, W.1.

MR. G. C. WALTON has been appointed sales manager to McKechnie Brothers, Ltd., Rotton Park-street, Birmingham, 16, with effect from July 1. Mr. Walton has been manager of the firm's branch at Newcastle-upon-Tyne for many years.

MR. E. B. SCHOFIELD has been appointed area sales engineer for Lancashire, Cheshire and the West Riding of Yorkshire to Elliott Brothers (London) Ltd., Century Works, Lewisham, London, S.E.13. He will specialise in electrical measuring instruments and operate from the company's office at 66 Deansgate, Manchester, 3. (Telephone: Blackfriars 7752.)

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BUSINESS CHANGES

HONEYWELL-BROWN LTD., Wadsworth-road, Perivale, Middlesex, have opened an additional office in Glasgow, at 26 Blythswood-square, and have appointed MR. D. J. VENNING to be district supervisor in charge.

The SOLAR AIRCRAFT COMPANY, San Diego, California, U.S.A., have opened a European branch office, under the management of Mr. Patrick Johnson, A.F.C., C.P.A., A.F.R.Ae.S., at 8 Clarges-street, London, W.1. (Telephone: GROsvenor 7938.)

THE IRON AND STEEL INSTITUTE IN SWEDEN

In 1953, the Council of the Iron and Steel Institute accepted an invitation from the Council of Jernkontoret, the central organisation of the Swedish iron and steel industry to hold a special meeting in Sweden, from June 7 to 18, 1954. The last occasion on which the Institute met in Sweden was in September, 1926. The present meeting was divided into three sections, the first of which, from June 7 to 10, was held in Gothenburg and Västeras and the second, from June 10 to 13, in Stockholm. The third section, from June 13 to 18, comprised three simultaneous excursions by special sleeping-car trains to the steelmaking and iron-mining areas in Central and Northern Sweden.

The main party of members and ladies left Tilbury on Saturday, June 5 and arrived at Gothenburg on Monday, June 7. The first visits to works were paid on Tuesday, June 8, when members went to A.B. Ferrolegeringar, a works making high-grade ferro-alloys, and to a neighbouring 250-MW water-power station, at Trollhättan. Other visits were paid to the Gothenburg works of A.B. Svenska Kullagerfabriken (S.K.F.), A.B. Volvo, manufacturers of motor cars and lorries, and A.B. Götaverken, the principal shipbuilding centre in Sweden.

In the evening of Tuesday, June 8, a dinner was held at the Börsen, the Town Hall, Gothenburg, by invitation of the directors of the Götaverken, S.K.F. and Volvo companies. After dinner the visitors left by special sleeping-car train for Västeras. On arrival in the morning of Wednesday, June 9, excursions were made to the works of the (A.S.E.A.) Swedish General Electric Co. Ltd., ; the A.B. Svenska Metallverken, where copper and copper-alloy sheet, strip, rod and wire are produced; and the Surahammars Bruks A.B., one of the oldest steelworks in Sweden, now having a capacity of 100,000 tons of ingots and castings per annum and produces also rolled plates and sheet, largely for the electrical industry.

The visitors left Västeras in the afternoon of Wednesday, June 9, and arrived in Stockholm in the evening. In the evening of Thursday, June 10, a reception was held at the offices of Jernkontoret in Stockholm.

All the technical sessions were held in the Swedish Parliament building, the Riksdagshuset, in Stockholm. The first day's proceedings, on Friday, June 11, took the form of a discussion meeting of Jernkontoret and were in Swedish. The chair was taken, at 10 a.m., by Mr. Nils Danielsen, a member of Council of Jernkontoret and managing director of Uddeholms A.B. In the course of his introductory speech which was in Swedish, he also spoke in English welcoming the visiting metallurgists and saying that Swedish iron and steel men were glad of the opportunity thus given them to show something of what was being done in iron and steel and engineering works in Sweden.

Before proceeding to the presentation of papers, Mr. Evert Wijkander, President of the Council of Jernkontoret, presented the Rinman Gold Medal for 1954 to Professor M. Wiberg, of the Royal Institute of Technology, Stockholm, for his work in originating and perfecting a process for making sponge iron and also for his researches on blast-furnace plant and practice.

The remainder of the morning, and the whole of the afternoon, were devoted to the presentation and discussion of three papers by leading Swedish metallurgists.

SWEDISH IRON-ORE CONCENTRATION

The first paper, by Professor P. G. Kihlstedt of the Royal Institute of Technology, Stockholm, gave a survey of the present conditions influencing Swedish iron-ore beneficiation. He stated that he had investigated the choice of iron contents in the concentrates obtained from different types of ore in regard to the best possible adaptation for the coke blast-furnace process as applied in Sweden. To help in this study, an evaluation formula, based on the production costs of pig iron, had been established. The starting point was a fixed pig-iron price; from this had been deducted the costs of smelting, and the balance to be paid for the different concentrates had been calculated. The cost functions with regard to the compositions of the concentrates had then been analysed and the formula obtained. For the utilisation of Swedish Apatite iron ores (which contain so-called phosphate of lime) in home pig-iron production, high concentration was a matter of importance. It had also been ascertained that flotation methods would raise the recovery of iron in the beneficiation of hematite ores.

CALCULATIONS IN HOT ROLLING

The second paper was by Professor Gunnar Wallquist, also of the Royal Institute of Technology, Stockholm, and dealt with the " Calculation of Roll Pressure and Energy Consumption in Hot Rolling." The author stated that his investigations had shown that the calculation of roll pressure and energy consumption in hot rolling could be based either on a mathematical analysis of the deformation or on empirical values obtained experimentally during rolling, the latter method being the only reliable one at present. The influence of the steel composition, temperature, reduction and of the thickness of the material, roll pressure, energy consumption, spread and forward slip had been studied in 16 steels, and tests made in the new experimental rolling mill at the Royal Institute of Technology, Stockholm. The results had been brought together in diagrams, showing, for each of the 16 steels, the variation of the numerical values of total and specific roll pressure, roll-pressure coefficient, rolling power, torque-arm coefficient, coefficient of spread, and forward slip with temperature, reduction, and material thickness. The present paper gave only a brief account, limited mainly to five of the steels investigated. A complete account of the results obtained would be published later as a special research report.

DEEP-DRAWING PROPERTIES OF SHEET STEEL

The third paper was entitled " Deep-Drawing Properties of Sheet Steel: Fundamental Principles and Test Methods," and was by Dr. Olov Svahn, of Sandvikens Jernverks, A.B., Sandviken. The author stated that, in 1945, a research project had been started by Jernkontoret, the intention being to study existing methods of testing the deep-drawing properties of steel; to develop, if possible, more reliable testing methods; and to study the correlation between test results and practice. Owing to its complicated nature, deep-drawing with the material sliding needed a test which approximated in all respects to the deep-drawing process. Deep-drawing with pure elongation was easier to test, and a modification of the Erichsen test was quite satisfactory. The test properties must be fixed with great accuracy and the criterion for drawing quality must be the pressing force at the point of rupture, instead of the depth of rupture, as measured in the normal subjective manner. The possibility of classifying materials having small variations in physical properties was at present under investigation at Sandviken. The test methods would shortly be presented to corresponding organisations in other countries in an attempt to arrive at an international standard for testing drawing qualities.

To be continued

British Electrical Power Convention

CONSULTING ENGINEERS AND THE ELECTRICAL INDUSTRY

The sixth British Electrical Power Convention was held at Eastbourne from Monday, June 14, to Friday, June 18, under the presidency of Mr. J. R. Beard. Some 38 organisations, which are constituent members of the Convention, were represented and the attendance numbered over 2,000. The theme of the Convention this year was the promotion of electrical development at home and overseas, this subject being dealt with from various aspects both in the presidential address and in the five papers, which were presented for discussion.

As on previous occasions, a feature of the proceedings was an exhibition of technical and domestic electrical appliances organised by the British Electrical Development Association. It was opened by the President on Monday evening, June 14, and was largely attended both by the delegates and the general public during the week.

PRESIDENTIAL ADDRESS

The first formal meeting was held in the Winter Garden on Tuesday, June 15, when a civic welcome was accorded to those attending by the Mayor of Eastbourne (Councillor L. W. Pyle).

The President then delivered his address, in which he said that his fellow consulting engineers welcomed his election as a recognition of a profession which by tradition had its light so much hidden under a bushel. There should be wider recognition of the functions of the consulting engineer and, in particular, of the contribution he could make to the promotion of electrical development at home and overseas. This contribution tended to be underestimated by the governments, bankers, economists and planning authorities, especially in relatively underdeveloped countries.

A well recognised advantage of the use of consulting engineers was that the client, as had been recorded by the British Electricity Authority, could base his design staff on normal long-term requirements and avoid the enlistment of personnel to deal with the inevitable peaks which occurred in all programmes of capital works. The overall effect was a more economical use of the technicians of the country, which incidentally, would help to deal with the present shortage, particularly teachers.

THE CONSULTING ENGINEER AND OVERSEAS TRADE

Consulting engineers could be divided into three categories: individuals prepared to advise on unusual technical problems, of which they had specialised knowledge; firms of small or medium size, particularly concerned with electrical installations for industrial concerns and large buildings; and a comparatively few firms, with large staffs dealing with the largest schemes, who were in a position to employ the highest grade of specialists in all branches of their work. It was these large firms which could be most helpful to this country in the expansion of overseas trade. The most important of their overseas activities was, in fact, that they acted as a spearhead for the engineering export trade. This did not mean that the consulting engineers were expected to place their contracts with British

firms. Their tradition was to act in the best interests of their clients. Unless this position was made clear to prospective overseas clients, the inevitable result would be to undermine the confidence which was so essential in carrying out large projects abroad.

PREPARATION OF SPECIFICATIONS

In the client's interests the designs and specifications should be such as to ensure that the requirements were not only adequately defined, but that, where world tenders were invited, unnecessary restrictions were not introduced which might tend to handicap any responsible tenderers. The right of the contractor to fair treatment, while the work was being carried out, must also be recognised. Many overseas specifications were drawn in such a way as to make it difficult for British manufacturers to quote. The chief value of British consulting engineering to our export trade was therefore to ensure that our manufacturers had a fair and proper consideration of their offers; and to benefit the client by extending the field of competition.

UNDERDEVELOPED COUNTRIES

Great Britain's wide experience of world problems and its reputation for dealing with these problems with proper regard to the interest of the countries concerned should enable us to make a significant contribution towards raising the standards of living in the wide underdeveloped areas of Asia, Africa and elsewhere. The wealth of a nation lay broadly in the skill, intelligence, initiative and capacity for hard and accurate work of its peoples and electrical engineers, by providing the power which was the mainspring of more efficient industry, agriculture and domestic life, could play a large part in creating the material conditions necessary for such increase.

It must be made clear, however, that our desire to assist in these developments was as much in the interests of these countries as of our own; and that this was one of the cases when both parties benefitted. Undue emphasis on our superior skill and knowledge should be avoided and the natural desire of engineers in such countries to do such work as they thought they were capable of doing efficiently should be recognised. If the client did not give the consulting engineer his full confidence the results were argument, delay, frustration and duplication. Hence the importance of cultivating the professional and ethical outlook of the British consulting engineer and of endeavouring to make overseas clients to appreciate it and obtain its full development.

FACTORS HAMPERING WORK OVERSEAS

Two requirements of professional practice in this country were that consulting engineers should not advertise or solicit work. Although there was no suggestion that there should be any change in this attitude in Great Britain, there was a growing appreciation that a strict interpretation of these principles would make it extremely unlikely that British consulting engineers would receive many appointments in some countries overseas. This matter was being continuously pressed upon the Association of Consulting Engineers by the Board of Trade who had a keen appreciation of the value of consulting engineers and a vivid realisation of the handicaps which our rigid professional code placed upon them, compared with the much greater freedom allowed, or at least taken, by many firms from North America and the Continent. Any relaxation should, however, be made with caution although there was no reason for not discussing a problem which was undoubtedly of great importance to this country.

FINANCIAL ORGANISATIONS

A most important factor in overseas electrical developments was the means by which projects were encouraged by arrangements for technical assistance and by loans. In both of these, consulting engineers were directly concerned. This, however, was not as widely appreciated as it should be. In respect of finance the provision of private capital for overseas had become almost negligible, especially for public utility purposes and such finance had therefore to be provided through various government agencies.

The six principal organisations concerned with promoting profits in underdeveloped countries were: The Technical Assistance Board (T.A.B.) of the United Nations Organisation (U.N.O.); the Foreign Operations Administration (F.O.A.) of the United States; the Colombo Plan; the International Bank for Reconstruction and Development; the Export-Import Bank of Washington; and the Colonial Development Corporation to which the Commonwealth Development Finance Company had recently been added. After giving a brief survey of the activities of these agencies, the President said that some of them, and particularly T.A.B., seemed to make a practice of providing individual experts rather than advice from consulting engineers. This was not the best way of studying large public utility projects and required some examination since its relative inefficiency was not always apparent in non-engineering circles.

No individual could be thoroughly conversant with all the details of a complex engineering scheme and have the accumulated experience of those large firms of consultants who were accustomed to dealing with both the engineering and economic aspects of a project. Many of the latter had permanent organisations in Commonwealth countries and, in addition, had staff seconded to particular projects all over the world. Another aspect was the difficulty of recruiting sufficiently able individuals; modern engineering was essentially team work and all the best men were part of some team. In consequence, important projects involving vast expenditure were often reported on by those who were far from being the most able.

Apart from efficiency there was the question of cost. Experts who were asked to take up temporary assignments ran some risk of interruption to their careers, and only did so for exceptional remuneration and from a strong sense of public duty. Consulting engineers, on the other hand, were organised for the purpose of providing such advice.

THE "ALL-IN" BIDS POLICY

The practice, which had been developed in the United States, Asia and Europe, of "all-in" bids for complete projects was not usually in the interests of the clients; and the client-consultant-contractor relationship based on the practice of obtaining competitive tenders was likely to produce a better and cheaper job. For this reason, and at the urgent request of the Board of Trade, consideration was being given to arrangements whereby British consulting engineers would assist a group of contractors in the designs necessary for a comprehensive tender, subsequently carrying out their conventional duties in connection with manufacture and erection on behalf of the group. It should always be possible, however, for the client to appoint a consulting engineer directly after the comprehensive offer had been accepted.

The report of the convention will be continued in subsequent issues.

ELECTRICITY SUPPLY

Lord Citrine on Recent Developments

In the course of an address to members of the Area Electricity Boards attending the British Electrical Power Convention at Eastbourne on Monday, June 14, Lord Citrine said that the substantial progress made in the industry since vesting date was maintained during the year ended March 31, 1954. The consumption of electricity increased by 6·9 per cent. over the previous year. Despite increased capital and operating costs, it was estimated that the over-all revenue per kilowatt-hour rose slightly.

The shortage of steel which occurred two years ago had adversely affected the commissioning of generating plant, during 1953, amounting to 1,413 MW as compared with 1,539 MW in 1952. It was anticipated that the upward trend would be resumed in 1955, and would rise to 1,950 MW in 1959. Turbo-alternators, each with a capacity of 200 MW, were being planned for commissioning in the 1959 programme. These sets were to be installed in the power station to be built at High Marnham on the River Trent, some ten miles from Newark.

The over-all thermal efficiency of generation was 23·22 per cent. for the calendar year 1953, as against 20·87 per cent. at the vesting date. Had the thermal efficiency in 1953 been the same as in the twelve months preceding the vesting date, an additional 4 million tons of coal would have been burned at a cost of £12 million.

Availability of generating plant had maintained the progressive improvement of recent years, and in order to expedite repairs the Central Authority had decided to establish a limited number of their own central workshops.

REDUCTION IN POWER CUTS

There was only one power cut during the winter, and 21 instances of voltage and frequency reduction, compared with six power cuts and 86 instances of voltage and frequency reduction in the winter 1952-53. On February 2, 1954, the plant carried the record load of 15,430 MW. This compared with 9,501 MW during the winter preceding the vesting date.

Because of the possibility of a coal shortage, the Central Authority were considering the use of dual firing for coal or oil at the Marchwood (Hampshire) station and were examining the position in respect of 16 other stations situated on the estuaries of rivers. Close co-operation had been established between the Central Authority and the Atomic Energy Authority, and staffs would be trained in the design, construction and operation of nuclear power reactors for the generation of electricity.

The construction of the 275-kV super-grid was proceeding satisfactorily, the first 40 miles been successfully inaugurated in July, 1953. Valuable information was gained from the cable-laying trials made last summer for the projected cross-Channel interconnection.

Research continued through the laboratory at Leatherhead, which was being extended; through pilot and operational plant, and through the research associations and the universities. The 15 MW gas turbine at Trafford Park was undergoing running trials, and the 100-kW wind-power plant was nearing completion.

Rural development had been speeded up, and 12,941 farms were connected last year, or about three times as many as before the war. 60,000 additional farms would be connected by 1958, and a further 45,000 by 1963.

District heating and similar projects were under consideration at Bloom-street (Manchester), Spondon, Stepney and Warrington.

HARBOURS AND SHIPPING

Work of The Permanent Association of Navigation Congresses

The annual general meeting of the British Section of the Permanent International Association of Navigation Congresses was held at the Institution of Civil Engineers, London, S.W.1, on June 10, the chair being taken by Sir William Halcrow, M.I.C.E.

In the annual report of the British Section, which was presented and adopted, it was stated that a delegation of 15 members of the Section, headed by Sir William Halcrow, had attended the 18th International Congress at Rome, from September 15 to 22, 1953, and that six of the members had presented papers there. The Congress was attended by some 850 delegates, from 48 nations. The British delegates included Sir Reginald Hill, who acted as chairman of the Inland Navigation sessions, and Mr. William Mackenzie, who took the chair at one of the Maritime Section meetings.

Work on the International Technical Dictionary was being continued, and Mr. M. Nachshen, the British member of the Dictionary Committee, had prepared the English text of the fourth-coming Chapter VI, on "Water and the Sea," from the French original. Arising out of the discussions at Rome, the Secretary-General of the International Association requested the British National Committee to co-operate with the secretary of the American Section in making a comparison of the methods of loading general cargo in European and American ports, and the rates of loading achieved. The British Committee, in the report, expressed regret that little progress had been made so far by the special Committee on Depths in Sea Ports, set up last year; but four panels had been set up to consider, respectively, the types of ships required by shipowners and the reasons for their choice; tendencies in the design of ships, and any structural limitations or developments; the design of port works, to meet changing ship dimensions; and the economic effects of those changes on shipowners and ports.

The ballot to fill vacancies on the committee of the British Section resulted in the election of Mr. J. T. Evans, O.B.E., M.I.C.E., Mr. C. W. N. McGowan, M.I.C.E., and Professor Jack Allen, M.I.C.E.

During the discussion of the report, emphasis was laid on the desirability of increasing the membership of the British Section of the Association, especially in view of the decision, recently taken at a meeting of the Permanent Committee in Brussels, that the next Congress, in 1957, should be held in Britain. The view was expressed that many shipowners, naval architects, and officials of dock and harbour authorities, etc., might have been deterred from joining because they did not realise closely how the work of the Association was concerned with their own functions, interests and activities. It was agreed unanimously that steps should be taken to correct any such impression and to increase the membership of the Section.

The proceedings closed with a vote of thanks to Sir William Halcrow for his services as chairman of the Section, a position which he has held since its inception, but which he had expressed the wish to relinquish. He will remain a member of the British National Committee, the address of which (and that of the secretary) is c/o the Institution of Civil Engineers, Great George-street, London, S.W.1.

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GAS MANUFACTURE DISPLAY AT THE SCIENCE MUSEUM: ERRATUM

We regret that, on page 742, *ante*, we stated incorrectly that the Gas Gallery at the Science Museum was opened on Tuesday, May 25, by Colonel Sir Harold Smith, chairman of the Gas Council. It was in fact opened by the Lord President of the Council, Lord Salisbury.

LAUNCHES AND TRIAL TRIPS

M.S. "ELLEN BAKKE."—Single-screw cargo vessel, built and engined by the Götaverken Shipyard, Gothenburg, Sweden, for Knut Knutsen O.A.S., Haugesund, Norway. Main dimensions: 507 ft. overall by 63 ft. 6 in. by 41 ft.; deadweight capacity, 10,430 tons on a draught of 28 ft. 7 in. Götaverken nine-cylinder single-acting two-stroke Diesel engine, developing 8,200 b.h.p. at 112 r.p.m. Loaded speed, 17 knots. Delivered, May 4.

M.S. "BRITISH GUNNER."—Single-screw oil tanker, built and engined by Harland and Wolff, Ltd., Govan, Glasgow, for the British Tanker Co., Ltd., London, E.C.2. Main dimensions: 490 ft. between perpendiculars by 65 ft. by 36 ft.; deadweight capacity, about 14,000 tons. Harland-B. and W. six-cylinder two-stroke single-acting opposed-piston Diesel engine. Trial tip, May 5.

M.S. "TABRIZ."—Single-screw oil tanker, built and engined by Eriksbergs Mek. Vertstads Aktiebolag, Gothenburg, Sweden, for Wilh. Wilhelmsen, Oslo, Norway. Main dimensions: 526 ft. between perpendiculars by 69 ft. 9 in. by 39 ft. 3 in.; deadweight capacity, about 18,000 tons on a draught of 30 ft. 5 in.; oil-tank capacity, about 854,850 cub. ft. Eriksberg-B. and W. eight-cylinder two-stroke single-acting oil engine, developing 10,000 b.h.p. at 115 r.p.m. Service speed 16½ knots. Delivered, May 17.

M.S. "NORTH CORNWALL."—Single-screw cargo vessel, built by Bartram and Sons, Ltd., Sunderland, for the North Shipping Co., Ltd. (Managers: Hugh Roberts and Son), Newcastle-upon-Tyne. Main dimensions: 425 ft. between perpendiculars by 58 ft. 9 in. by 38 ft. to shelter deck; deadweight capacity, 9,900 tons on a draught of 26 ft. 1 in. N.E.M.-Doxford four-cylinder opposed-piston oil engine, developing 3,300 b.h.p. at 109 r.p.m. in service. Speed, 12¼ knots. Launch, May 18.

M.S. "PINDAR."—Single-screw cargo vessel, built by Short Brothers, Ltd., Sunderland, for the Commercial Maritime Finance Corporation, Panama. Main dimensions: 450 ft. between perpendiculars by 61 ft. by 38 ft. 8 in. to shelter deck; deadweight capacity, about 10,300 tons on a mean summer draught of 26 ft. 7½ in. Eight-cylinder single-acting two-stroke oil engine, developing 5,600 b.h.p., constructed by Sulzer Brothers, Ltd., Winterthur, Switzerland, and installed by the North Eastern Marine Engineering Co. (1938), Ltd., Sunderland. Service speed, 14 knots. Trial trip, May 18.

M.S. "REGENT ROYAL."—Single-screw oil tanker, with accommodation for twelve passengers, built by the Blythswood Shipbuilding Co., Ltd., Scotstoun, Glasgow, for Trinidad Leaseholds, Ltd., London, W.1. Main dimensions: 487 ft. between perpendiculars by 65 ft. 6 in. by 35 ft. 4 in.; deadweight capacity, 14,400 tons. Rowan-Doxford four-cylinder two-stroke opposed-piston heavy-oil engine, developing 4,500 b.h.p., constructed by David Rowan & Co., Ltd., Glasgow. Mean trial speed, 14·3 knots. Trial trip, May 18.

M.S. "HUNTSLAND."—Single-screw cargo vessel, built by the Burntisland Shipbuilding Co., Ltd., Burntisland, Fife, for the Power Steamship Co., Ltd. (Managers: O. Gross and Sons, Ltd.), London, E.C.3. Main dimensions: 450 ft. between perpendiculars by 64 ft. by 40 ft. 5 in. to shelter deck; deadweight capacity, 11,650 tons on a draught of 27 ft. Hawthorn-Doxford six-cylinder opposed-piston Diesel engine, arranged to burn heavy-fuel oil, and developing 6,600 b.h.p. Machinery installed by the shipbuilders. Launch, May 20.

M.S. "SWIFTPOOL."—Single-screw cargo vessel, with accommodation for a small number of passengers, built by the Caledon Shipbuilding and Engineering Co., Ltd., Dundee, for Sir R. Ropner & Co. (Management), Ltd., Darlington, County Durham. Main dimensions: 485 ft. overall by 63 ft. 3 in. by 40 ft. 9 in. to shelter deck; gross tonnage, 6,725; deadweight capacity, 9,870 tons on a draught of 27 ft. 3¼ in. Stephen-Doxford six-cylinder opposed-piston heavy-oil engine, developing 7,500 b.h.p., constructed by Alexander Stephen and Sons, Ltd., Linthouse, Glasgow. Trial trip, May 24.

M.S. "GOLDEN BAY."—Twin-screw vessel for the carriage of cement in bulk, built by Henry Robb, Ltd., Leith, for the Tarakohe Shipping Co., Ltd., Wellington, New Zealand. Main dimensions: 245 ft. overall by 42 ft. by 18 ft.; deadweight capacity, about 1,100 tons on a draught of 12 ft. 6 in. Two four-cylinder Diesel engines, together developing 1,260 b.h.p. at 250 r.p.m., constructed by British Polar Engines, Ltd., Glasgow. Each engine drives one propeller through a magnetic coupling and alternator unit manufactured by the British Thomson-Houston Co., Ltd., Rugby. Service speed, 10 knots. Delivered, May 27.

BOOKS RECEIVED

Elements of Structural Engineering. By ERNEST C. HARRIS. *The Ronald Press Company, 15 East 26th-street, New York 10, N.Y., U.S.A.* (7 dols.)

Diesel and High Compression Gas Engines—Fundamentals. By EDGAR J. KATES. *The Technical Press, Limited, 1 Justice-walk, Lawrence-street, London, S.W.3.* (44*s.*)

The Grinding of Steel. By ERIC N. SIMONS. *Odhams Press, Limited, 96 Long Acre, London, W.C.2.* (25*s.*)

Analysis Directory of Canadian Coals. By E. SWARTZMAN. Second edition. *Canadian Department of Mines and Technical Surveys, Mines Branch, Fuels Division, Ottawa, Canada.* (2·50 dols.)

Practical Sheet and Plate Metal Work. By E. ARTHUR ATKINS. Sixth edition by W. A. ATKINS. *Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2.* (20*s.*)

The Mathematical Solution of Engineering Problems. By MARIO G. SALVADORI. With a collection of problems by KENNETH S. MILLER. *Oxford University Press (Geoffrey Cumberlege), Amen House, Warwick-square, London, E.C.4.* (34*s.*)

A Concise History of Mathematics. By DIRK J. STRUIK. *G. Bell and Sons, Limited, York House, Portugal-street, London, W.C.2.* (14*s.*)

Report of H.M. Principal Electrical Inspector of Mines for the Year 1951. Ministry of Fuel and Power. *H.M. Stationery Office, Kingsway, London, W.C.2.* (1*s.* 6*d.*)

Costa Rica. Overseas Economic Survey. By C. N. EZARD. Published for the Board of Trade, Commercial Relations and Exports Department, by *H.M. Stationery Office, Kingsway, London, W.C.2.* (1*s.* 6*d.*)

Fuel for the Nation: The Gas Industry's Programme. *The Gas Council, 1 Grosvenor-place, London, S.W.1.* (1*s.*)

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TRADE PUBLICATIONS

Marine Boilers. The third students lecture presented at The Institute of Marine Engineers, London, on December 14, 1953, by R. E. Zoller, M.I.Mar.E., entitled Babcock Marine Boilers, has been published in the form of a booklet by Babcock and Wilcox, Ltd., Babcock House, Farringdon-street, London, E.C.4.

Earth Boring Machines. We have received from The Earth Boring Machine Co., Lake Works, Portchester, Hampshire, a copy of their leaflet describing the standard range of Magco earth-boring machines now available. The machines are hydraulically operated and the type DHH is suitable for boring holes of 24 in. diameter by 8 ft. deep. It can be tilted 5 deg. aft and 15 deg. sideways.

Rotary Indicators. A leaflet published by Teleflex Products, Ltd., Teleflex Works, Chadwell Heath, Essex, describes the Telerev rotary indicator. This instrument has been designed for attachment to the centre of handwheels. It has a glazed dial and two indicator hands. One hand indicates rotary movement in increments of 10 deg. and the other hand records 36 complete turns. A typical application is on the handwheel of a screw-down valve.

Oil. The Petroleum Information Bureau, 29 New Bond-street, London, W.1, have published an illustrated booklet tracing the sequence of operations between the discovery of a new oilfield, the production and conveyance of crude oil and its subsequent conversion into refined products. A brief note is also given of the uses made of the by-products.

Cooling Tubes for Refrigerators. A booklet describing "Integron" finned tubing for use in Freon-12 water-cooled condensers has been published by the Imperial Chemical Industries Ltd., Imperial Chemical House, Millbank, London, S.W.1. Tables and formulæ are given for calculating the length of tubing required.

Street Lighting. Published by the British Electrical Development Association, 2 Savoy-hill, London, W.C.2, a booklet sets out the case for better street lighting in the campaign against road casualties.

Superheaters for Steam Plant. A booklet issued by the Superheater Co. Ltd., 53 Haymarket, London, S.W.1, deals with the applications of superheaters in modern steam plant, and gives some 35 examples of recent installations.

Annual Meeting of the Iron and Steel Institute (*concluded from page* 785)

STRUCTURAL CHANGES IN CAST IRON

All the seven papers at the morning session on Thursday, May 27, of the recent annual general meeting of the Iron and Steel Institute were discussed jointly after presentation. All dealt with some aspect of the structural changes in cast iron during solidification or on heating.

STRUCTURE OF CAST IRON

The first paper, entitled "Eutectic Solidification of Grey, White and Mottled Hypo-Eutectic Cast Irons," described work carried out at the Swedish Institute for Metal Research (Metallografiska Institutet), Stockholm. The authors, Professor A. Hultgren, Mr. Y. Lindblom and Professor E. Rudberg, stated that they had studied solidification, under controlled conditions, in four hypo-eutectic cast irons, conditions being selected to produce coarse graphite, fine "undercooled" graphite, a mottled structure, and a white iron. Samples had been quenched at predetermined points on the cooling curves, and sections examined for evidence of the processes occurring during cooling. With small samples and drastic quenching, regions that had not been reached by reaction formed a microstructure of fine "quench" ledeburite (a cementite eutectic), which contrasted with any "furnace" structure formed during furnace cooling. The graphite-austenite constituent, of eutectic composition, of such furnace structures generally had the form of rounded rosettes; its formation was associated with a characteristic cooling curve, and its fineness was closely correlated with the temperature of its formation. The formation of cementite-austenite eutectic was associated with a cooling curve of different shape. In the mottled iron investigated, graphite-austenite was formed in specimens quenched in the early stages of cooling, corresponding to a "graphite" cooling curve. In the later stages of cooling, the curve assumed the form characteristic of cementite-austenite formation; this was also revealed by the microstructure of specimens quenched at this stage.

The second paper dealt with "The Structural Changes during Annealing of White Cast Irons of High Sulphur: Manganese Ratios" and was by Professor A. Hultgren and Mr. G. Ostberg. It described work carried out at the Royal Institute of Technology, Stockholm, the authors stating that they had studied, by examining the microstructures of quenched specimens, the mechanism of formation of dispersed graphite-flake "nests," compact graphite nests, and graphite spherulites during annealing, at 900 to 1150 deg. C., of white cast irons of different, but mainly high, S : Mn ratios. Any one of the three types of graphite aggregate mentioned could be produced at will by a suitable combination of S : Mn ratio of the iron, hydrogen content of the annealing atmosphere, and annealing temperature. Several interface combinations, not only those involving sulphide, appeared to favour the nucleation of graphite. In this way, an iron or manganese sulphide inclusion could serve as a nucleating particle for a graphite spherulite.

In the third paper, on "The Growth of Nodular Graphite," Mr. M. Hillert and Mr. Y. Lindblom discussed work conducted at the Swedish Institute for Metal Research, Stockholm. They suggested that graphite spherulites grew by screw dislocations generated by the inclusion of foreign atoms in the graphite lattice. The authors added that the lattice defect referred to as a screw dislocation was well known and that crystal growth by screw dislocations had now been demonstrated for many materials and appeared to be a common phenomenon. In support of their theory, the authors concluded, a rare-earth element had been found, by means of autoradiography, to be uniformly distributed through the spherulites present in a nickel-carbon alloy treated with *mischmetall*.

The fourth paper was concerned with "The Solidification of Nodular Iron," and was by Mr. H. Morrogh, of the British Cast Iron Research Association. He stated that cooling-curve and quenching experiments indicated that graphite nodules could form directly from the liquid. Graphite nodules could also be formed by the decomposition of acicular carbide. It appeared that the rate of diffusion of carbon from the liquid through the austenite envelopes was the controlling feature of the solidification process. The more nodules present in a given volume of metal the greater the rate at which this diffusion could occur. When the cooling rate was so high that the rate of diffusion of carbon on the austenite could not satisfy the transfer requirements, the remaining liquid would solidify as acicular carbide, which might decompose subsequently.

The fifth paper, on "Undercooled Graphite in Cast Irons and Related Alloys," was by Mr. H. Morrogh and Mr. W. J. Williams, of the British Cast Iron Research Association. They stated that undercooled graphite resulted from the decomposition of a carbide, some of which might be formed before the eutectic arrest. This carbide was hypereutectic in character, from which it derived its acicular appearance. Undercooled graphite in relatively high-silicon alloys had been found to arise from the decomposition of a mixture of silico-carbide and cementite. The analysis of carbide extracted from iron-carbon-silicon alloys pointed to the existence of a silico-carbide of relatively low carbon content.

In the sixth paper, on "The Solidification of Iron-Phosphorus-Carbon Alloys," Mr. H. Morrogh and Mr. P. H. Tütsch stated that, in place of the normal ledeburite, phosphorus in small amounts in iron-phosphorus-carbon alloys caused the formation of a degenerate eutectic structure. In large amounts, phosphorus gave rise to austenite dendrites and cementite of hypereutectic appearance. An interesting parallel had been observed in 1950, in the effect of sulphur on the structure of ledeburite by Mr. W. J. Williams, who had shown that this element also could initiate a degenerate structure with a tendency to give acicular carbides.

The seventh and last paper concerned with the structure of cast iron was by Dr. A. Berman and Dr. V. Kondic of the Department of Industrial Metallurgy at the University of Birmingham, and dealt with the "Decomposition of Cementite during Solidification of Cast Iron." The authors stated that Mr. H. Morrogh and Mr. W. J. Williams had concluded that the two types of graphite, designated *D* and *A* according to the standards of the American Society for Testing Materials and the American Foundrymen's Association, were of different origins; *D* was thought to be the product of the decomposition of cementite, while *A* was formed directly from the liquid. To provide information on the problem of the origin of graphite, and, in particular, to study the conditions under which it came from the liquid or as a result of cementite decomposition, a series of experiments had been designed to measure the time needed for graphite to form at the eutectic temperature and to compare this time with that required for the decomposition of cementite below the eutectic.

The results obtained had confirmed that type D graphite could form by the decomposition of cementite immediately after its solidification. It had also been indicated that the graphite forming during the eutectic arrest could also be a product of cementite decomposition. No general deduction, however, could be made concerning the origin of type D graphite under all other conditions, and no conclusion could yet be drawn from the present results concerning the origin of other types of graphite.

DISCUSSION

The discussion was opened by Dr. N. P. Allen, who stated that in work of this kind investigators would have to take a great deal of care to work on small amounts of material and to be careful regarding the amount of refractory they put round the sample, so that the rate of heating and cooling in the neighbourhood of the chosen temperature for the experiment was rapid when it was required to be rapid and slow when it was required to be slow.

With regard to the question of why the graphite sometimes had a spherulitic form and sometimes a flake form, he felt that the explanation offered by the Swedish authors, that the transition from one form to the other was somehow connected with the relative rates of growth at the edge of the graphite flake, was an acceptable one. The sequence of structures from spherulitic to flake graphite indicated that the spherulitic graphite was formed when the rate of growth of the graphite was, by some action or impurity, decreased.

Professor Axel Hultgren stated that it was often said that hypo-eutectic irons solidified first by forming austenite and then a second phase appeared, which could be cementite or graphite. His own view was that at that moment the eutectic reaction was initiated, which he thought was not in accordance with the general findings of Mr. Morrogh, who had spoken of graphite or cementite forming in a hypo-eutectic cast iron before the eutectic reaction, and he would like Mr. Morrogh to explain that point. It appeared, that regardless of the form or distribution of the second solid phase, it must be a eutectic reaction since two solid phases were present.

Dr. R. V. Riley said that the fundamental conception of the metallurgy of cast iron had for many years been undergoing a change. In the early days of Professor Turner, the simple iron-carbon diagram appeared capable of representing a cast-iron alloy with a sufficient degree of accuracy. Now, owing to the recent developments which had taken place in the malleable field and with nodular-graphite irons, this simple concept did not appear to be adequate. The mode of formation of graphite and the equally important subject of carbide formation and breakdown had, of course, received most attention. The work at the British Cast Iron Research Association had demonstrated beyond reasonable doubt the existence of a silico-carbide in addition to cementite, thus confirming the original ideas of Dr. W. H. Hatfield and, much later, many other workers, including himself.

The vexed problem of where the graphite in the iron came from – whether from the liquid or the solid – had been apparently solved by a compromise in the papers. It came from both. The British workers, however, appeared to indicate that graphite in hypo-eutectic iron could come directly from both the silico-carbide and from cementite, but this, apparently, was not completely acceptable to Swedish investigators.

The nature of the phosphitisation in iron had been made almost childlike in its simplicity. The paper presented by Mr. Morrogh and Mr. Tütsch was remarkable in its brevity and its clarity.

IRON-CARBON DIAGRAM

The form of the iron-carbon diagram still appeared to be a major unknown quantity, and from the point of view of knowing what the iron-carbon diagram could bring to further the metallurgy of cast iron, metallurgists must hope for some further excellent work from sources in Sweden and from the British Cast Iron Research Association.

Mr. Gustaf Ostberg said that it was much appreciated that Mr. Hillert and Mr. Lindblom had introduced the technique of radioactive tracer elements into their study of graphite. Previous attempts had been made to find out whether graphite contained other elements than carbon, and the usual way had been to dissolve the matrix surrounding the graphite and analyse the graphite by different means. The disadvantages of these early methods were quite clear; elements in the graphite could be taken out by

the acid, or, during the preparation of the experiment, elements from the surrounding matrix could be brought into the graphite.

AUTHOR'S REPLY

Mr. H. Morrogh, in a brief reply, said that on the question of the formation of undercooled graphite he would like to remind the audience of a practical experience which happened every day and determined the method of operating the production of certain castings. In Scotland there was a foundry which produced rain-water gutters. The mould was made in two parts; it was a cast iron mould about 15 ft. long. The top half of the mould was hinged along one edge, molten metal was poured in, the mould was closed and the excess molten metal squeezed out. Now the people who made these castings – and they made thousands of them every day – had found by experience that unless they stripped the casting, which was approximately $\frac{1}{4}$ in. thick, from the mould as soon as it had solidified, it would turn out white. In order to obtain grey iron castings they must strip the casting from the mould as soon as it had solidified, and it had that form of graphite which was called undercooled graphite. He would like to hear from those people who postulated that all undercooled graphite formed directly from the liquid, how this circumstance arose.

The observations, by Professor Hultgren and Mr. Ostberg, on the growth of graphite particles, were interesting and perhaps they might be fairly summarised as follows, namely that heat-treating white cast iron of high-sulphur content at high temperature gave a pronounced tendency for spherulites to form. Most of the authors' observations had been made at temperatures when one would expect some liquid metal to be present: liquid partly by virtue of the very high temperatures at which they were carrying out these experiments and partly by virtue of the high-sulphur content, and also because some of their samples contained significant quantities of phosphorus.

It was quite clear that in the presence of sulphur there was a tendency for spherulite formation, and, in certain circumstances, while there was some liquid available there was a tendency for film-like formation of graphite at interfaces.

In ordinary cast irons free from elements such as lead, titanium, antimony and bismuth, magnesium, as was well known, produced graphite spherulites, but when there were present small amounts of these elements, which were referred to as "subversive elements," the magnesium did not produce spherulites and if the metal were cooled fairly rapidly structures very similar to those produced by sulphur were formed.

The meeting was then adjourned until the afternoon.

SWEDISH ROLLING-MILL PRACTICE

On the afternoon of Thursday, May 27, four papers, all dealing with various phases of rolling-mill design or practice in Sweden, were presented and then discussed jointly.

The first paper was entitled "New Swedish Mill Designs and Layouts for Medium and Small Sections and Wire Rod" and was by Mr. S. E. M. Norlindh, of Mekaniska Verkstads A/B, Morgardshammar, Sweden. The author stated that the development of rolling-mill technique in Sweden had been directed mostly towards the need of the small high-grade steel-works for the economical production of bars and wire rods. New designs of roller guides had permitted repeater rolling not only of breakdown ovals but also of leader ovals. (The repeaters consist of curved guides serving to bring the end of a bar around and returning it to the rolls for the next pass.) Hitherto repeaters had been used for finish rolling material between 0·2 in. and 2 in. in diameter. Using a new kind of whip channel it was now possible to roll down to 0·2 in. at a speed of from 3,700 to 4,300 ft. per minute in alternating two-high mills.

With the conditions prevailing in Scandinavia, high-productivity continuous wire-rod and bar mills and cross-country mills could not generally be used. As a rule, a limited output of from 10,000 tons to 100,000 tons a year was required and this production covered a wide range of sizes, from 0·2-in. to 6-in. rounds and squares, and strips varying from about $\frac{3}{8}$ in. up to 8 or 12 in. wide. Rolling mills in Scandinavia were restricted to three-high and alternating two-high mills. The finishing-mill layout formerly employed, consisting of one medium-section mill, one small-section mill, in certain cases combined with a wire-rod mill, and sometimes also a strip mill, had been replaced by a combined rolling mill for medium and small sections and wire rod. The medium-section mill usually had five three-high stands. In addition to the finish rolling of medium sections, this mill served as a roughing mill for the small-section and wire-rod mills.

The second paper dealt with "The New Fagersta Wire-Rod Mill" and was by Mr. K.-E. Pihlblad, who stated that the mill had been designed to produce 35,000 tons of wire rod, ranging from 0·2 to 0·236-in. in diameter, per annum, working in two eight-hour shifts. It was put into operation in 1950 and consisted of a pusher-type furnace fired by producer gas; a roughing mill with two three-high stands and one two-high stand, nine wire-rod trains comprising 18 alternating two-high stands, two wire-rod reels, and a hook conveyor. A good tolerance was obtained on the rolled rod, and the wire rod could be delivered with a guaranteed tolerance of $\pm$ 0·004 in.

The third paper was on the subject of "Roller-Bearings in Swedish Rolling Mills and the S.K.F. Rolling-Mill Design." The author, Mr. A. Leufvén, stated that Swedish rolling mills had begun using roller bearings at the end of the 1920's At the commencement of the 1940's, the S.K.F. oil-injection method of lubrication had been introduced and this had provided opportunities for improving roller-bearing applications in rolling mills. At the end of the late war it had been decided by S.K.F. to create a rolling-mill design in which the qualities and advantages of the spherical roller-bearing could be utilised to the full, and in which the desirability of very little deflection and the possibility of rapid roll changing could be achieved. The Fagersta wire-rod mill and plant for the Sandviken, Wikmanshyttan and Degerfors works was of S.K.F. design, as were also the rolling mills for copper-wire rod and for aluminium-wire rod of the Svenska Metallverken at Västeras.

The last paper considered dealt with "Practical Experience in the Use of Repeaters in a Looping Mill" and was by Mr. H. W. Riddervold. He stated that with the looping mill recently introduced, it was important that the reliability of operation should be not less than that of the continuous rolling mills. The present repeater design made it easy to roll ovals and squares, and certain other profiles. The use of cast-iron repeaters without moving parts made possible two ways of mounting and keying them to the stands. It was usual to have three-point support for the repeaters; the simplest way was to use the exit-guide support as one rest point and to let the floor provide the other two. The other method of assembling a repeater was to rest it on two supports attached to the foundation, on which it could be moved laterally, and on an adjustable leg at the rear end. Guide pipes were provided for guiding the stock from the delivery guides to the repeater and from the repeater to the entry guides. In practice, the most difficult tasks were teaching the rolling staff the necessary accuracy and having enough spare guides available at all times.

DISCUSSION

Mr. T. W. Hood, who opened the discussion, said that the subject dealt with involved a description of how to obtain a medium output from flexible mills. The types of mills which could be used for this purpose could be grouped in three classes. The first were those using repeaters throughout in the intermediate and finishing trains. The second were those which repeated the sections, with the stands grouped in pairs Thirdly, there were the mills having looping intermediate trains and tandem continuous finishing trains. It was said that roller bearings were more generally adopted in rolling mills in Sweden than in this country. In a modern mill in Sweden, it would be a peculiarity to find a bearing which was not a roller bearing.

Mr. R. Stewartson said that for persons who were used to a continuous rod mill, the first feature which would strike them concerning the layout given by Mr. Norlindh was the long path which the bar had to travel in coming from the roughing stand to the final rod stand. From the author's illustrations the path was seen to be about 1,000 ft. long. That compared with 300 to 400 ft. in a modern high-speed rod mill. He wondered whether this long path resulted in a low overall temperature and whether the low finishing temperature presented any difficulty with the alloy steels – the difficult steels – which the Author mentioned. In a continuous rod mill a drop of something like 300 deg. C. would be expected between the furnace and the last stand. Turning to the repeaters, the remarks which the authors had made concerning whip were very much to the point, but he had found that with a repeater between the two stands, each with individual electrical drive and a fine speed control available, it was possible to loop up to 2,000 feet a minute and keep the bar more or less within the channel, thus controlling the whip when the bar left the preceding stand. In other words, a fine speed control helped a great deal in controlling whip. That was something which could not be done when two stands were driven from one motor, as described in the papers.

Mr. W. Craig said that it was apparent that the trend of design in Sweden was to produce a unit which would have a wide diversity of products and at the same time require only a minimum of manpower. In that respect Swedish engineers had proved themselves to be most ingenious. They had gone a long way in their quest for 100 per cent. automatic operation. That seemed to be the trend of design throughout all these stands which had been described in the papers.

Mr. H. D. Thompson stated that Mr. Norlindh had described various interesting and revolutionary features in rolling mill practice – a new stand design, high-speed repeaters, excellent roller entry guides, pre-stressed stands with setting devices, very versatile layouts, and so on. One of the main advantages was the very small space occupied. With regard to yield, Mr. Riddervold had said that yield had gone up recently and that, on small products, it was 93 per cent. In a continuous rod mill in this country a 96 per cent. yield would be expected. That difference of 3 per cent. in yield, even on a mill rolling 100,000 tons a year, represented about 3,000 tons.

Mr. M. Langew stated that it had been pointed out that there was a long distance between the medium mill and the small-section mill to deliver the bar, but there was an even longer distance from the last finishing stand to the coilers.

Mr. S. E. M. Norlindh, in the course of his reply, stated that the distance between the roughing and the small-section train depended entirely on the length it was desired to roll in the medium-section train. The maximum lengths of bars rolled in straight lengths had been of the order of about 100 feet. The medium-section train would be increasingly used for repeater rolling of finished sizes. With respect to yield when rolling, the billet size was of importance. When rolling 2-in. billets in the continuous mill the yield would be very much higher than when using $3\frac{1}{2}$ in. or 4 in. billets. There was a good deal of difference because it was necessary to cut the front and tail ends more. Furthermore, the scale was less when rolling from small-size billets.

Mr. A. A. Leufvén also briefly replied, after which the chairman thanked the authors of all the papers for their contributions and declared the meeting closed.

REINFORCED HOLES IN PLATES

TOTAL WEIGHT REDUCED BY VARYING THICKNESS OF REINFORCEMENT

By Raymond Hicks, M.SC.

The presence of a circular hole in a flat plate loaded in its own plane results in an increase of the stress concentration. If the hole is small compared with the lateral dimensions of the plate its effect on the stress distribution will be local whereas a large hole may appreciably alter the stress distribution in the whole plate. The effect of suitably reinforcing the hole is to decrease the maximum stress in the plate so that when the stress in the plate is to nowhere exceed a given value the presence of the reinforcement results, except in the case of large holes, in a decrease in the necessary weight of the structure. The design of a reinforcement is therefore an important problem when the weight of the structure must be as low as possible, as, for example, holes in the skin of an aircraft.

This investigation deals with a reinforced hole in an infinite plate uniformly stressed in one direction. The reinforcement, probably of the same material as the plate, has a variable rectangular cross-section so designed that its tensile resistance is proportional to the tangential stress which occurs around the hole in a similarly-loaded unreinforced plate. The advantage of a reinforcement of this type is that no material is wasted in reinforcing parts of the hole where the accompanying stresses are always relatively low. Thus, when the weight of the structure is an important factor, a reinforcement of this type is more efficient than a reinforcement having a constant cross-sectional area.

Expressions are obtained below for the radial, tangential and shear stresses in the plate. These expressions are written in terms of a set of constants which can easily be evaluated for any particular numerical example. It is found that the concentration of stress is local so that the solution can be applied to a finite plate provided its width is several times greater than the diameter of the hole. It is worth noting that by using suitable stress functions the method used to solve this problem can be used to find the stress distribution in plates subjected to either a pure shear or unequal principal stress distribution around the outer boundary.

THEORETICAL ANALYSIS

For an infinite plate uniformly stressed in the direction of the x-axis the boundary conditions at infinity are

$$(rr)_\infty = \frac{f}{2}(1 + \cos 2\theta). \quad . \quad (1)$$

$$(r\theta)_\infty = -\frac{f}{2}\sin 2\theta. \quad . \quad . \quad (2)$$

where rr, $r\theta$ and $\theta\theta$ are the stress components in polar co-ordinates, f the applied stress, and r and θ the co-ordinates of the point considered.

Around the hole the boundary conditions are obtained by considering an element of the reinforcement subtended by an angle $\delta\theta$, as shown in the diagram. There is assumed to be no shear on a radial cross-section of the reinforcement because its bending stiffness in the plane of the plate is small. This follows from the work of Gurney* who concluded that reinforcements which have a relatively small bending stiffness in the plane of the stressed plate experience primarily tensile and compressive stresses as opposed to bending stresses.

* C. Gurney, "An Analysis of the Stresses in a Flat Plate with a Reinforced Circular Hole under Edge Forces." *Aeronautical Research Council Reports and Memoranda*, No. 1834 (1938).

For force equilibrium in a radial direction

$$F = b\,h\,(rr)_b. \quad . \quad . \quad (3)$$

where F is the normal force acting on a cross-section of the reinforcement, h is the thickness of the plate, and b the radius of the hole measured to the centre of the reinforcement. Similarly, for force equilibrium in a tangential direction

$$\frac{dF}{d\theta} = -\,h\,b\,(r\theta)_b. \quad . \quad . \quad (4)$$

A further boundary condition is obtained by equating the strain in the reinforcement to the tangential strain in the adjacent part of the plate. That is,

$$\frac{F}{A_R} = (\theta\theta - \nu\, rr)_b, \quad . \quad . \quad (5)$$

where A_R is the cross-sectional area of the reinforcement at the point considered and ν is Poisson's ratio.

Equation (5) can be combined with equation (3) to give the following boundary condition

$$(\theta\theta - \nu\, rr)_b \frac{A_R}{b\,h} - (rr)_b = 0. \quad . \quad (6)$$

The stresses around a hole in an unreinforced plate uniformly stressed in one direction are

$$(rr)_b = 0. \quad . \quad . \quad . \quad . \quad (7)$$

$$(r\theta)_b = 0. \quad . \quad . \quad . \quad . \quad (8)$$

and $$(\theta\theta)_b = f(1 - 2\cos 2\theta). \quad . \quad (9)$$

From equation (9) it is seen that the presence of the hole increases the maximum stress in the plate from one to three. The effect of suitably reinforcing the hole is to decrease the stress concentration in the plate, and in this analysis the reinforcement is designed so that its cross-sectional area varies in a similar manner to the tangential stress given by equation (9).

The area of the reinforcement can therefore be written

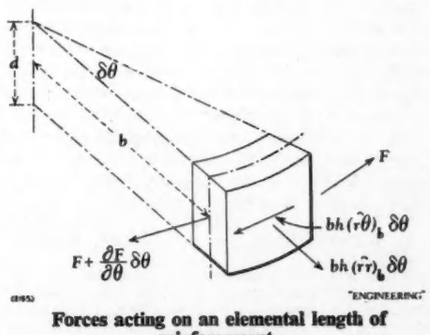
$$A_R = \alpha' + \beta'\cos 2\theta, \quad . \quad (10)$$

where α' and β' are constants which are chosen so that $\alpha' + \beta'$ is the area of the reinforcement when $\theta = 0$, and $\alpha' - \beta'$ is the area of the reinforcement when $\theta = \frac{\pi}{2}$. The advantage of a reinforcement of this type is that its effectiveness in decreasing the tangential stresses around the hole increases as the tangential stresses tend to increase.

Using the value of A_R given by equation (10), the boundary condition specified by equation (6) can be written as

$$(\theta\theta - \nu\, rr)_b(\alpha + \beta\cos 2\theta) - (rr)_b = 0, \quad . \quad . \quad . \quad (11)$$

where α has been written for $\frac{\alpha'}{b\,h}$ and β for $\frac{\beta'}{b\,h}$.



Forces acting on an elemental length of reinforcement.

If ϕ is a function which satisfies the equation

$$\left(\frac{\partial^2}{\partial r^2} + \frac{1}{r}\frac{\partial}{\partial r} + \frac{1}{r^2}\frac{\partial^2}{\partial\theta^2}\right)^2 \phi = 0, \quad (12)$$

the stresses in the plate are given by

$$(rr) = \frac{1}{r}\frac{\partial\phi}{\partial r} + \frac{1}{r^2}\frac{\partial^2\phi}{\partial\theta^2}. \quad . \quad (13)$$

$$(\theta\theta) = \frac{\partial^2\phi}{\partial r^2}. \quad . \quad . \quad . \quad . \quad (14)$$

$$(r\theta) = -\frac{\partial}{\partial r}\left(\frac{1}{r}\frac{\partial\phi}{\partial\theta}\right). \quad . \quad (15)$$

The solution of equation (12) which can be made to satisfy the boundary conditions is

$$\phi = A\log r + Br^2\log r + Cr^2 + D + \sum_{n=2}^{\infty}\left[a'_n r^n + b'_n r^{n+2} + \frac{a_n}{r^n} + \frac{b_n}{r^{n-2}}\right]\cos n\theta, \quad . \quad . \quad . \quad (16)$$

where n is always even and A, a_n, b_n, etc., are constants which must be chosen to satisfy the boundary conditions. If A, B, C and D are zero and $\sin n\theta$ is substituted for $\cos n\theta$, the resulting stress function can be used to solve the problem of a variably reinforced hole in a plate having a pure shear distribution applied at its outer boundary.

Using equation (16), the components of stress become

$$rr = \left\{\frac{A}{r^2} + B(1 + 2\log r) + 2C - \sum_{n=2}^{\infty}\left[n(n-1)a'_n r^{n-2} + (n^2 - n - 2)b'_n r^n + n(n+1)\frac{a_n}{r^{n+2}} + (n^2 + n - 2)\frac{b_n}{r^n}\right]\cos n\theta\right\}. \quad (17)$$

$$\theta\theta = \left\{-\frac{A}{r^2} + B(3 + 2\log r) + 2C + \sum_{n=2}^{\infty}\left[n(n-1)a'_n r^{n-2} + (n+2)(n+1)b'_n r^n + n(n+1)\frac{a_n}{r^{n+2}} + (n-2)(n-1)\frac{b_n}{r^n}\right]\cos n\theta\right\}. \quad (18)$$

$$r\theta = \left\{\sum_{n=2}^{\infty} n\left[(n-1)a'_n r^{n-2} + (n+1)b'_n r^n - (n+1)\frac{a_n}{r^{n+2}} - (n-1)\frac{b_n}{r^n}\right]\sin n\theta\right\}. \quad . \quad . \quad . \quad (19)$$

For the stresses in the plate to remain finite as $r \to \infty$, it is found that

$$\left.\begin{aligned} B &= 0 \quad . \quad . \quad . \quad . \\ a'_n &= 0 \text{ when } n \neq 2 \quad . \quad . \\ b'_n &= 0 \text{ when } n > 2 \quad . \quad . \end{aligned}\right\}. \quad (20)$$

To satisfy the boundary conditions given by equations (1) and (2)

$$C = -\,a'_2 = \frac{f}{4}. \quad . \quad . \quad (21)$$

Combining equations (3) and (4), the following boundary condition is obtained

$$\frac{\partial}{\partial\theta}(rr)_b + (r\theta)_b = 0. \quad . \quad (22)$$

This condition is satisfied when

$$b_n = \left(\frac{f\,\delta_2}{4} - \frac{a_n}{b^{n+2}}\right)b^n, \quad . \quad (23)$$

where $\delta_2 = 1$ when $n = 2$, and $\delta_2 = 0$ when $n \neq 2$.

Using the values for the constants given by equations (20), (21), (22) and (23), the expressions for the stress components become

$$rr = \frac{A}{r^2} + \frac{f}{2} - \sum_{n=2}^{\infty}\left[\frac{a_n}{r^n}\left\{n\left(\frac{n+1}{r^2}\right) - \left(\frac{n^2 + n - 2}{b^2}\right)\right\} + f\,\delta_2\left\{\frac{b^2}{r^2} - \frac{1}{2}\right\}\right]\cos n\theta. \quad . \quad . \quad . \quad (24)$$

$$\theta\theta = -\frac{A}{r^2} + \frac{f}{2} + \sum_{n=2}^{\infty}\left[\frac{a_n}{r^n}\left\{n\left(\frac{n+1}{r^2}\right) - (n-2)\left(\frac{n-1}{b^2}\right)\right\} - \frac{\delta_2 f}{2}\right]\cos n\theta. \quad (25)$$

$$r\theta = -\sum_{n=2}^{\infty}\left[n\frac{a_n}{r^n}\left\{\left(\frac{n+1}{r^2}\right) - \left(\frac{n-1}{b^2}\right)\right\} + \frac{f}{2}\delta_2\left\{1 + \frac{b^2}{r^2}\right\}\right]\sin n\theta. \quad (26)$$

It is worth noting that these expressions for the stress components are independent of the cross-sectional area of the reinforcement. They are, therefore, valid for any type of reinforcement provided its bending stiffness in the plane of the plate is negligible. Furthermore, by applying the principle of superposition, these expressions can be used to find corresponding expressions for the stress distribution in a plate subjected to a pure shear or unequal principal stress distribution around the outer boundary. The stress components given by equations (24), (25) and (26) are written in terms of the arbitrary constants A and a_n which must be chosen to satisfy the boundary condition given by equation (15). Substituting the appropriate values for $(\theta\theta)_b$ and $(rr)_b$ in equation (15), the following set of equations are obtained for the constants A and a_n. These equations are obtained by equating to zero the coefficient of each term containing $\cos n\theta$ in the boundary condition given by equation (15). That is,

$$\sum_{n=0}^{\infty}\left\{N\delta_0 + M\delta_2 + \frac{2a_n}{b^{n+2}}[\alpha(2n-1+\nu)+1] + \beta\left[(2n-5+\nu)\frac{a_{n-2}}{b^n} - \frac{f\delta_4}{4}(1-\nu) + (2n+3+\nu)\frac{a_{n+2}}{b^{n+4}}\right] = 0\right\}. \quad (27)$$

where

$$N = \frac{f}{2}[\alpha(1-\nu) - 1] - \frac{A}{b^2}[\alpha(1+\nu)+1] - \frac{\beta}{4}f(1-\nu),$$

$$M = \frac{\beta}{2}f(1-\nu) - \frac{A\beta}{b^2}(1+\nu) - \frac{f}{2}[\alpha(1-\nu)-1],$$

$\delta_0 = 1$ when $n = 0$, $\delta_0 = 0$ when $n \neq 0$,
$\delta_2 = 1$ when $n = 2$, $\delta_2 = 0$ when $n \neq 2$,
$\delta_4 = 1$ when $n = 4$, $\delta_4 = 0$ when $n \neq 4$,
$a_2 = a_0 = 0$.

Equation (27) depends on the stress distribution applied to the plate and the cross-sectional area of the reinforcement. These equations can only be used for the particular problem considered in this paper, but similar equations can readily be obtained for plates having other types of applied stress distributions and reinforcements different from the one considered here. In practice, it is found that the ratio $\frac{a_n}{a_{n+2}}$ is large enough to enable the stress components to be evaluated from the first four or five terms of the series given by equations (24), (25) and (26). Thus, if the first four terms are taken in the series for the stress components, the constants A, a_2, a_4 and a_6 are determined by solving the four equations obtained by putting $n = 0$, 2, 4 and 6 in equation (27).

When the hole is unreinforced $\alpha = \beta = 0$ and equation (27) gives the following values for the constants,

$$A = -\frac{fb^2}{2},$$

$$a_2 = -\frac{fb^4}{4},$$

and $a_n = 0$ when $n \neq 2$.

If the reinforcement has a constant cross-sectional area, $\beta = 0$ and the expressions for the constants are

$$A = -\frac{f}{2}\left[\frac{1+\alpha\nu-\alpha}{1+\alpha\nu+\alpha}\right]b^2. \quad (28)$$

$$a_2 = -\frac{f}{4}\left[\frac{1+\alpha\nu-\alpha}{1+\alpha\nu+3\alpha}\right]b^4. \quad (29)$$

and $a_n = 0$ when $n \neq 2$.

When r becomes several times greater than the hole diameter, the terms containing $\left(\frac{1}{r^n}\right)$ in equations (24), (25) and (26) can be neglected, and the stress components reduce to

$$rr = \frac{f}{2}(1 + \cos 2\theta). \quad . \quad (30)$$

$$\theta\theta = \frac{f}{2}(1 - \cos 2\theta). \quad . \quad (31)$$

$$r\theta = -\frac{f}{2}\sin 2\theta. \quad . \quad . \quad (32)$$

The effect of the hole is, therefore, local and for this reason the solution can be applied to a finite plate providing its width is several times greater than the diameter of the hole. As a numerical example, let

Poisson's ratio = 0·3,
diameter of hole = 5 in.,
thickness of plate = 0·04 in.,
width of reinforcement = 0·1 in.,
depth of reinforcement = 0·25 in. when $\theta = 0$, and depth of reinforcement = 0·5 in. when $\theta = \frac{\pi}{2}$.

For a hole and reinforcement having the dimensions given above, the first five constants in the expressions for the stress components are

$A = -0{\cdot}21067\,fb^2$
$a_2 = -0{\cdot}06617\,fb^4$
$a_4 = -0{\cdot}00671076\,fb^6$
$a_6 = -0{\cdot}000596\,fb^8$
$a_8 = -0{\cdot}000062475\,fb^{10}$.

Using these values for the constants it is found that the maximum stress in the plate occurs around the hole and acts in a tangential direction at the point $\theta = \frac{\pi}{2}$. Its value is $1{\cdot}525\,f$. Thus, the effect of reinforcing the hole is to decrease the maximum stress in the plate from $3f$ to $1{\cdot}525\,f$. The reinforcement considered above is equal in weight to a constant reinforcement having a depth of 0·375 in. For a reinforcement with this constant depth the maximum stress in the plate is obtained from equations (25), (28) and (29), and is found to be $1{\cdot}744\,f$.

MEASURING LOADS IN WIRES

TWO SIMPLE DEVICES TO ENSURE ACCURACY IN PRESTRESSING

By N. W. B. Clarke, M.ENG., M.I.C.E.*

The current methods of determining the load in prestressing wires, cables or rods, both in the factory and on site, usually depend either on a pressure gauge of the Bourdon-tube type installed in the hydraulic jacking system, or on the measurement of the total extension of the prestressing tendon.

An investigation at the Building Research Station† has shown that the former method is liable to considerable and variable error due to variations in jack friction, jack return-spring loading, erratic movement of the sliding abutment of a stretching bed, and inconsistencies of the gauge. Even in first-class conditions the jacks alone show a 2½ per cent. variation.

The second method depends on accurate foreknowledge of the stress-strain relationship of the wire at the working stress and it has been shown that the measurement of this relationship, in the usual manner on 2-in. gauge lengths, is uncertain, considerable variations being recorded on specimens from the same coil of wire, on specimens from different coils in the same consignment and on the same wire at different ages after drawing. Its accuracy has also been found to be adversely affected by unknown or uncertain movements of the abutments, by variation of the " pull in " of the wire grips and by any accidental lack of parallelism of the fixed and moving abutments. The resultant total error on a bed 15 ft. long may be of the order of 15 per cent. (but it will depend on the length of bed; the shorter the bed the bigger the error).

In the laboratory these sources of error are largely, or entirely, eliminated by the use of an accurately calibrated proving ring placed between the fixed abutment and the grip on the end of one of the wires, whereby the actual load in the wire, after all accidental movements have occurred, is closely known. It is felt, however, that the proving ring is too delicate a device for use in the field or factory and that its use calls for greater knowledge and skill than would normally be available in industrial production.

Attempts have therefore been made to devise load-measuring equipment that will approach the accuracy of the proving ring even in the hands of semi-skilled operatives. Two such devices have been developed and are described below. The first device, known as the Cambridge Tension Indicator, was developed in collaboration with the Cambridge Instrument Company, Limited, 13 Grosvenor-place, London, S.W.1. The second device was designed and made at the Building Research Station. Both devices were exhibited at the Institution of Civil Engineers' Conversazione, 1953.

STIFF DOUBLE-CANTILEVER STEEL SPRING

The Tension Indicator developed from the Cambridge Electrode Pressure Indicator, consists essentially of a very stiff double-cantilever steel spring which suffers only a very small deformation under loads within its working range, together with a dial gauge to measure a magnification of its deformation. It is shown in Figs. 1 and 2, opposite. Calibration relates the readings of a normal dial gauge to actual load. Alternatively, a dial gauge reading load direct over a single circle may be used.

Four such instruments of an early design, fitted with direct load reading dials, were calibrated at the Station and, under repeated loading, showed errors at usual working loads within ± 3 per cent. The later design illustrated in Fig. 2 had an error within ± 2 per cent.

As with the proving ring, the calibration of the spring may be disturbed by any abuse such as overloading, shock, or instantaneous off-loading

* Of the Building Research Station, Garston, Hertfordshire.

† The work described in this paper forms part of the programme of research of the Building Research Board of the Department of Scientific and Industrial Research, and is published by permission of the Director of Building Research.

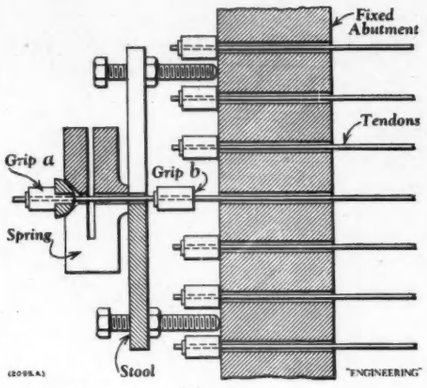


Fig. 1.

Figs. 1 and 2 The Cambridge Tension Indicator consists of a powerful double-cantilever steel spring which is deformed only slightly by the loads within its working range. It is mounted on a long-line stretching bed by the use of the reaction stool and the two grips on the control wire.

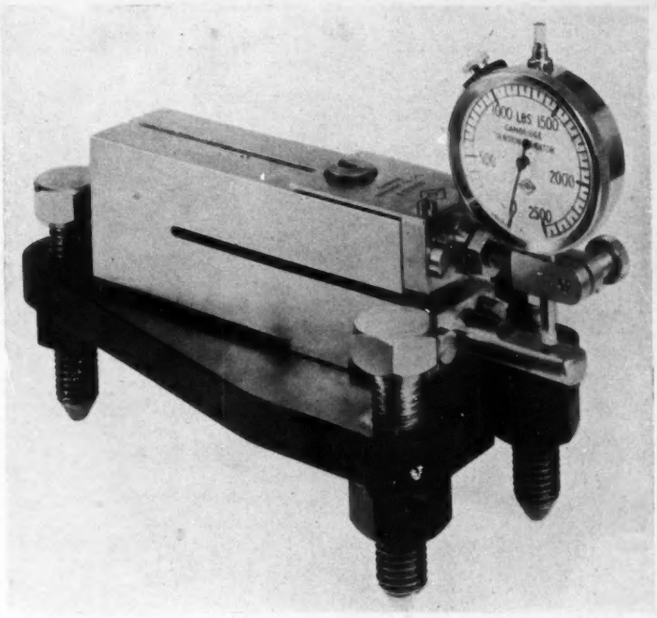


Fig. 2.

which occurs when a wire breaks. The dial gauge may also become unreliable for similar reasons, or if exposed to a moist or dusty atmosphere. For these reasons provision is made for easy stripping down and re-assembly of the instrument, enabling reconditioning of the spring or replacement of the gauge to be done quickly. Re-calibration is of course essential after any such action. For direct-reading dials an adjusting screw is provided to traverse the axis of the dial into its correct position.

To facilitate the installation of the gauge on any one of a group of wires and to free the gauge from a stretched wire, a three-legged reaction stool is used in conjunction with two wire grips. The outer grip *a*, shown in Fig. 1, bears on the spring through a spherical thrust block during the stretching operation. When the stretching operation is finished the inner grip *b*, Fig. 1, is pushed along the wire into contact with the abutment. The legs of the stool are threaded so that when they are turned appropriately the wire load is transferred from grip *a* to grip *b* and the instrument is off-loaded. Slots in the spring and in the spherical thrust block permit the removal of the instrument from the wire after off-loading, leaving the two grips on the wire.

The slotted thrust block bears on a conical seating and prevents any bending of the wire if the bearing face of the grip is not normal to the wire axis. The dial gauge can be turned about its axis into any convenient position for reading, and its zero can be adjusted by rotating the bezel.

The advantages of the Cambridge Tension Indicator are:

(1) Significant frictional errors are avoided and the accuracy of load measurement is ensured to within $\pm$ 2 per cent.

(2) Foreknowledge of the stress-strain relationship of the wire is not essential.

(3) Tension losses due to "pull in" of the grips, slight movement of the abutments and early creep of the wire are reduced or eliminated.

(4) If used, as described below, on one of a group of simultaneously stretched wires, the total load in all the wires is more positively known, than by the usual methods of load measurement.

(5) The same instrument may be used for various arrangements, lengths, and diameters of wire up to the limit of its load capacity.

(6) The instrument is compact and easily handled.

Its main disadvantages compared with the B.R.S. Tensometer are:

(1) Its greater margin of error.

(2) The fragility and liability to disorder of the dial gauge, especially in damp or dusty surroundings.

(3) The susceptibility of the spring to loss of calibration.

(4) The greater time taken in off-loading and re-loading by means of the screwed legs of the reaction stool.

The method of mounting and operation is almost identical with that for the B.R.S. Tensometer, described below.

These instruments are being made in two sizes at present, with maximum load capacities of 2,500 and 7,500 lb., respectively, and they may be obtained from the Cambridge Instrument Company.

BELL-CRANK LEVER

This appliance uses a dead-weight balance for the load in the wire and, by dispensing with springs and dial gauges entirely, is inherently more positive and reliable than the load-spring type of instrument. It was designed to provide, in a conveniently compact manner, the accuracy of the proving ring combined with robustness of construction and simplicity of operation and ability to maintain its accuracy unimpaired against relatively rough handling over long periods of time. It is believed that the 5,000-lb. prototype made at the Building Research Station has reasonably achieved these objectives. Factory experience is however required to confirm this view. Repeated tests against a proving ring and of the proving ring against a testing machine have shown that the Tensometer has a range of error no greater than that of the proving ring. The difference between the two instruments was always within $\pm$ 15 lb. throughout the loading range of 600 to 5,000 lb. and, at loads over 1,000 lb. was well within one half of one per cent., that is, the difference lies within the range of error of the proving ring.

The Tensometer proved very simple to operate on a long-line stretching bed when fitted with a tell-tale light, and the stretching operation could be comfortably carried out by one man operating the jack. Setting up and dismantling were simple, and called for no greater skill than that required to adjust the wire roughly in the centre of a hole in the abutment and to use a spirit level. After setting up, all that is required of the operator is to stop pumping when the tell-tale light goes out. Should it be feared that he might absent-mindedly ignore the light, a warning bell or hooter could be employed instead of the light.

The weighing device consists of a bell-crank lever having long and short arms at right angles and a horizontal low-friction fulcrum which bears against a fixed abutment. The short arm is normally vertical and carries one end of a wire at a precise distance from the fulcrum, and the long arm, which is initially set in a horizontal position by means of an adjustable stop, carries a predetermined counterpoise weight freely hanging from it, also at a precise distance from the fulcrum. The Tensometer is illustrated in Figs. 3, 4 and 5, herewith. When the wire is stretched sufficiently by a pull at its other end the lever rotates slightly about the fulcrum, the counterpoise weight becoming active and a measure of the load in the wire. The tell-tale light indicates exactly when the long arm is floating and the counterpoise weight active. Should slip or creep occur, permitting the wire to elongate, the lever settles back on to its stop re-establishing the lighting circuit and so giving warning of the relaxation. It is thus possible to adjust the wire tension to allow for early creep or other losses right up to the completion of concrete placing on a long-line casting bed. A circular spirit level mounted on the long arm facilitates setting up.

The device is calibrated initially against a proving ring or other standard, the knife edge carrying the counterpoise weight being moved slightly as necessary to make the lever ratio a precise round number (in the prototype, 20 to 1). The load imposed on the wire by the unloaded lever is also initially brought to a round figure, which remains a constant, K, for the instrument, by suitably adjusting the unladen weight of the counterpoise-weight carrier. Then, if the lever ratio is M and the added counterpoise weight is W, the load on the wire when the counterpoise becomes active is

$$T = K + MW,$$

and the weight W required to produce a given tension in the wire T is

$$W = \frac{1}{M}(T - K).$$

In the prototype M = 20, and K = 600 lb., so that for a tension of (say) 1,500 lb. in the prestressing wire, the required counterpoise weight is

$$W = \frac{1}{20}(1{,}500 - 600) = 45 \text{ lb.},$$

and for a tension of 4,500 lb., W = 195 lb.

It will be appreciated that the counterpoise

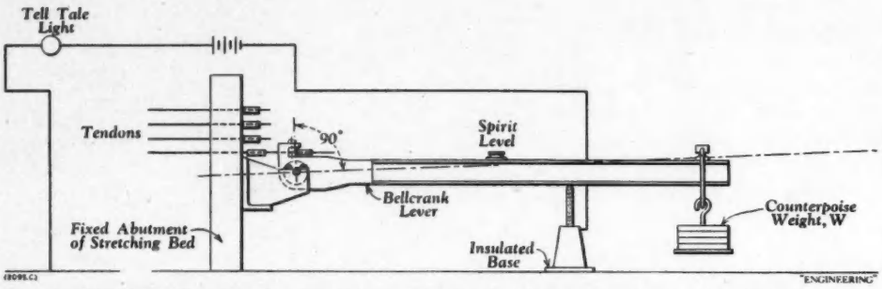


Fig. 3 The B.R.S. Tensometer mounted on a long-line stretching bed. It uses a deadweight counterpoise to balance the load in the wire and is inherently more positive and reliable than the loaded-spring type of instrument.

weights to be handled in setting up and dismantling are not excessive. A set of, say, four 50-lb. weights, two 20-lb., one 10-lb., and subsidiaries down to ½ lb. would enable the prototype to cope with any working load in wires up to 0·2 in. diameter to an accuracy of ± 10 lb. The counterpoise weights must of course be accurate themselves to within one half of one per cent. or better.

SPECIAL FEATURES

The only special features in the construction of the prototype are the use of standard needle bearings in the fulcrum and the use of rectangular thrust blocks for the wire anchorage. Both could be knife edges, but it was felt that the adopted construction was less liable to damage than knife edges and that setting up and dismantling would be easier with a self-supporting fulcrum. The thrust-block (one for each wire size) has a central tapered hole for the wire. The taper is towards the grip so as to ensure precision in fixing the effective length of the short arm of the lever and in its effective angle with the long arm, shown in Figs. 3 and 5, and to avoid bending the wire as the lever rotates.

The design of the bracket which carries the fulcrum and transfers the load to a fixed abutment must necessarily be governed by local conditions. In the prototype it was made for attachment to the fixed abutment of a long-line stretching bed. Its details are clearly shown in Fig. 5. The shape is not important but it is necessary to provide for a slight rotation in the vertical plane to enable the fulcrum pin to be brought to, and retained in, a level position after setting up the Tensometer. The attachment of the bracket to the fixed abutment must be robust and rigid so that no movement occurs during stretching, so that the lever does not become dislodged if the wire breaks.

The advantages of the B.R.S. Tensometer are:

(1) Instrumental and significant frictional errors are avoided and the accuracy of load measurement is ensured to within ± 1 per cent.

(2) Foreknowledge of the stress-strain relationship of the wire is not essential.

(3) Tension losses due to "pull-in" of the grip, slight movements of the abutments and early creep of the wire are reduced or eliminated.

(4) If used as described below on one of a group of simultaneously stretched wires, the total load in all the wires is more positively known within known limits of error than by the usual methods of load measurement.

(5) Apart from the initial calculation of the counterpoise weight, which should be done by a responsible person, the stretching operation requires no special skill, and instrument readings are avoided.

(6) The same instrument may be used for various arrangements, lengths and diameters of wires, up to the limits of its load capacity.

(7) The instrument is robust and unless flagrantly abused is unlikely to lose accuracy under factory or field conditions and it is not adversely affected by weather or temperature changes, or by a damp or dusty environment.

Its main disadvantages compared with the Cambridge Indicator are:

(1) The extra space occupied by the lever, which in the prototype is some 5 ft. beyond the fixed abutment.

(2) The need to handle weights.

(3) The possibly greater time taken in setting up and dismantling.

The device is the subject of a patent application; permission to manufacture should be sought from the National Research and Development Corporation, 1 Tilney-street, London, W.1.

METHODS OF USE

The methods described below are common to both instruments, except where otherwise stated. Both were designed primarily for use in pretensioning but either might be adapted for post-tensioning.

It is assumed that each of a group of wires of equal unstretched length and elastic characteristics will, when stretched equally and simultaneously, achieve the same tension. This assumption is supported by the experimental fact that the stress/strain ratio of a given sample of wire, at a given stress, is more consistent when measured on very long gauge lengths (tens of feet) than when measured on short gauge lengths (a few inches). In other words, on a long gauge length local variations are averaged.

Granted this assumption, it is necessary to know accurately the load in only one wire of a group, or, alternatively, the total extension required to produce that load.

The instruments may be used for either pretensioned or post-tensioned wires, in any one of the three ways described below, whichever may be most appropriate and convenient. With appropriate modifications the B.R.S. Tensometer might also be used for rods. For clarity, the following descriptions are confined to pretensioning; post-tensioning involves certain variations.

Method (i): *Independent Test Wire.*—By measuring the elongation of a long sample of wire at the required working load prior to and independently of the work in hand, and using this elongation to determine the total extension of similar wires in the work. This determination must be repeated for any and every change in wire or working load. In this method the instruments simply replace the usual laboratory testing machine but give a more accurate estimate of the required extension.

Method (ii): *Pilot Wire.*—Method (i) is still subject to the errors associated with the stretching bed, or individual moulds, and grips, which may be of the order of 10 per cent. on a 15-ft. length. By the use of an additional pilot wire, on the bed but clear of the work, to which the Tensometer

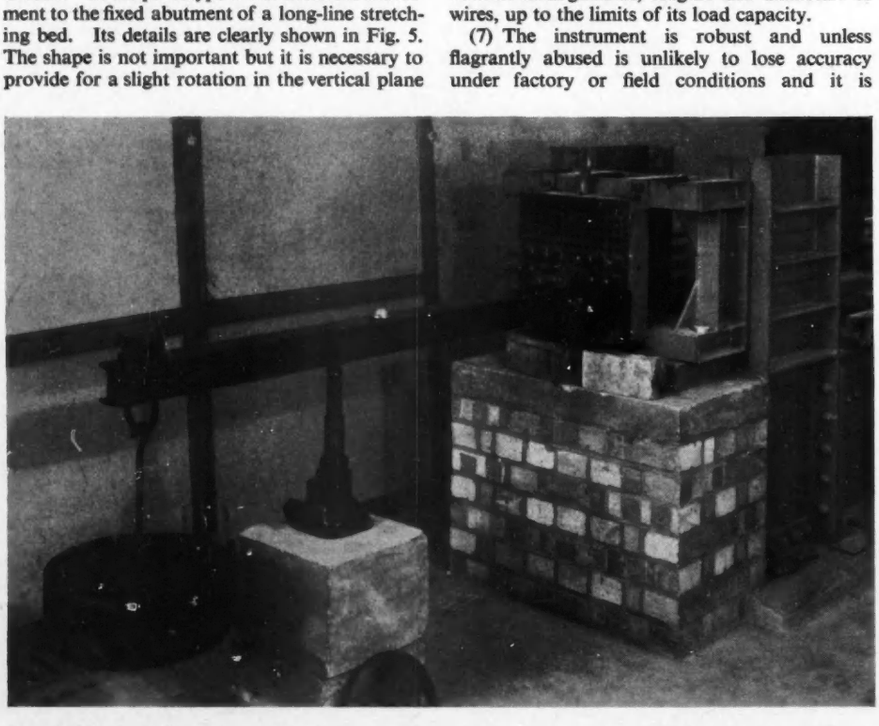


Fig. 4 The prototype Tensometer in use on a stretching bed; it is a basically simple appliance which ensures that the accuracy of load measurement is within ± 1 per cent. throughout the loading range of between 600 lb. and 5,000 lb.

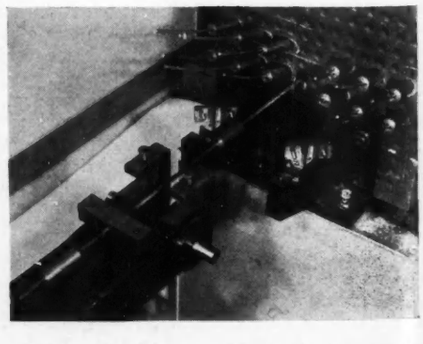


Fig. 5 The fulcrum end of the Tensometer dismantled to show the mounting on the supporting bracket and the position of the two grips.

s applied, these errors can be largely eliminated. All the wires including the pilot are stretched simultaneously until the working load as indicated by the Tensometer is reached. The safety screw jacks are then applied. If a second grip, *b* in Figs. 3 and 5, is used on the pilot wire, it is pushed up to the abutment and the instrument may then be off-loaded and released. When the jacks are finally off-loaded the pilot wire is released and may be withdrawn from the stretching bed.

Method (iii): *Control Wire.*—It may be convenient, and is perhaps usually preferable, to use one of the permanent wires instead of the additional pilot wire, as a control. This method is similar in operation to method (ii) except that, if grip *b* allows significant "pull in" of the control wire when the instrument is off-loaded, the load in the control wire will be less than that in the remainder of the group. To eliminate this error the instrument is reloaded, so drawing grip *b* away from the abutment. The resulting gap is closed by shims before the lever is finally off-loaded. This completes the normal stretching procedure.

COMPLETE ELIMINATION OF TENSIONING LOSSES

If, however, in either method (ii) or method (iii), it is desired to reduce tensioning losses still further, the lever may be left in the active position while concrete is placed in the work. Should creep or other elongation of the wires occur the lever will sink back on to its stop and bring the tell-tale light on again. The stretching jacks are then operated again until the light goes out, so taking up any losses that have occurred in the group of wires, and the safety screw jacks are adjusted accordingly.

The shims are then placed behind grip *b* on the control wire and the lever is off-loaded. The Tensometer may then be freed for use elsewhere, either by removing grip *a* or by cutting the wire between grips *a* and *b*.

The procedure with the Cambridge Indicator is similar in principle but the tell-tale light must be replaced by a second man to watch the dial gauge and to signal to the jack operator. The off-loading and reloading of the instrument are rather more cumbersome than with the Tensometer.

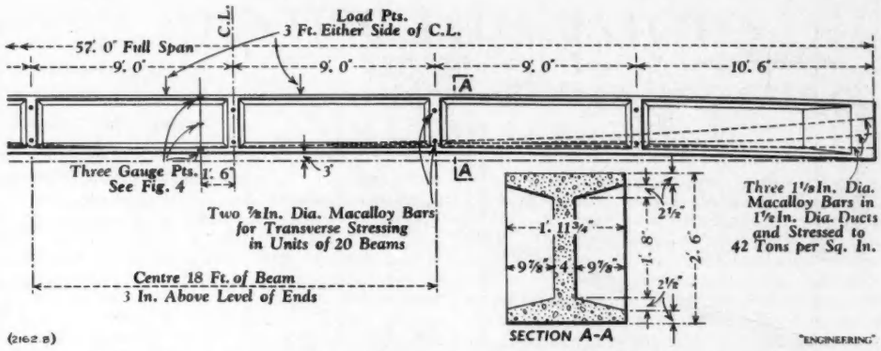


Fig. 1 This prestressed-concrete beam had a designed live-load moment of resistance of 3,855,000 lb.-in. At ultimate failure the beam had a factor of safety of 2·4.

FULL-SCALE TEST ON PRESTRESSED CONCRETE BEAM*

55-FT. SPAN BEAM LOADED TO DESTRUCTION

At the request of the Lee Conservancy Catchment Board the Cement and Concrete Association carried out the following full-scale test to destruction on a 55-ft. span Lee-McCall prestressed beam. The beam was designed for a culvert 55 ft. wide and approximately 2,140 ft. long which was to be covered by similar beams placed side by side in groups of twenty and joined by transverse stressing rods. The beam chosen for the test was the first to be manufactured and was tested 48 days after casting.

TABLE I.—*Design data for test beam*

Effective area of section, A	280·5 sq. in.
Effective second moment of area of section, I ..	36,155 in.⁴
Eccentricity of prestressing rods at centre span, *e*	11·6 in.
Design dead load moment, M_D	1,470,000 lb. in.
Design live load moment, M_L	3,855,000 lb. in.

Each beam was cast in two sections, approximately two-thirds and one-third respectively of the total length of 57 ft., and mortar-joined before stressing with three 1⅛-in. diameter Macalloy bars and grouted at 50 lb. per sq. in. with a neat cement grout. The section of the beam was of I shape with a depth of 2 ft. 6 in. and a width of 1 ft. 11¾ in., there being five full-width web stiffeners along the length. The I section increased to the full rectangular section at each end. The principal design data is given in Table I, and the details in Fig. 1, above.

* This article has been prepared from the report by Dr. P. B. Morice, A.M.I.C.E., who is in charge of the Structural Laboratory of the Cement and Concrete Association.

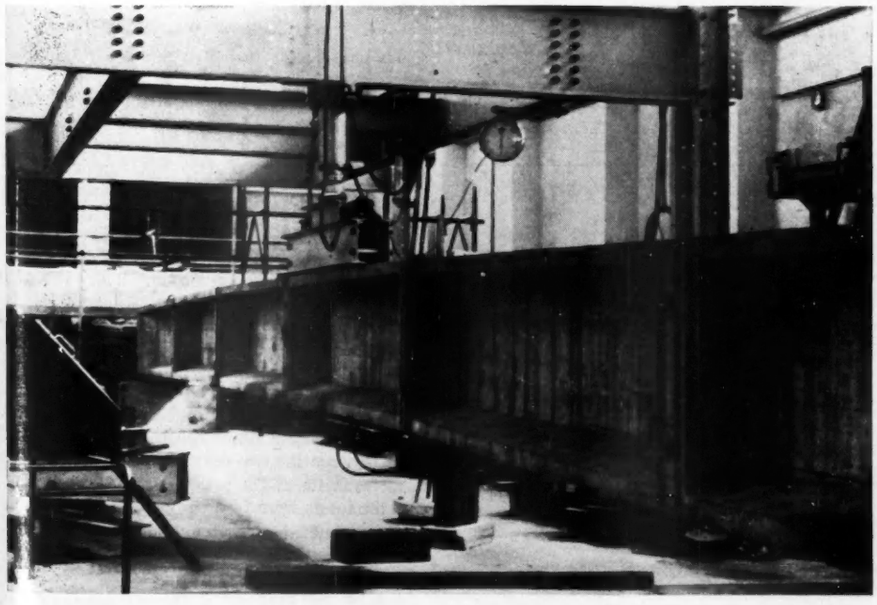


Fig. 2 Testing arrangements on a 55-ft. span prestressed concrete beam. The load was applied through a 6-ft. distributing beam straddling the mid-span.

TESTING ARRANGEMENTS

The test was carried out with the beam simply supported on a 55 ft. span, and the live load was applied to the top flange of the beam, at two points 3 ft. each side of the span centre, by means of a hydraulic jack and distributing beam. The test arrangement is illustrated in Fig. 2, below. The jack force was measured by means of a "statimeter" placed between the piston head and the distributing beam. With this arrangement the design bending moment of 3,855,000 lb.-in. was produced in the centre 6-ft. length of the beam with a jack force of 11·7 tons.

During the test measurements were taken of the central deflection of the beam, and the strain in the concrete was measured on three gauge lengths on one side of the beam only, 1 ft. 6 in. from the span centre, as indicated in Fig. 1. The strain gauge used was of the demountable mechanical type with an 8-in. gauge length.

The procedure adopted in the test was to apply the load to the beam in small increments until the centre span stresses were slightly in excess of their design values, and then to release the load. The load was again applied up to a maximum of 1·5 times the design condition and released. Finally the load was again applied and increased until failure occurred.

LOAD CAPACITY

The applied load which caused failure of the beam was 27·9 tons, equivalent to a bending moment of 9,200,000 lb.-in. at the centre of the span. With the dead load moment of 1,470,000 lb.-in. the ultimate moment had a value of 10,670,000 lb.-in.

An estimate of the ultimate moment, $M_{ult.}$, of a prestressed beam can be made using the expression

$$M_{ult.} = A_s\, t_{ult.} \left(1 - 0{\cdot}5\, p\, \frac{t_{ult.}}{C_r}\right) d,$$

where

A_s = steel area, 2·98 sq. in.;
$t_{ult.}$ = ultimate strength of Macalloy bars; 150,000 lb. per sq. in., allowed;

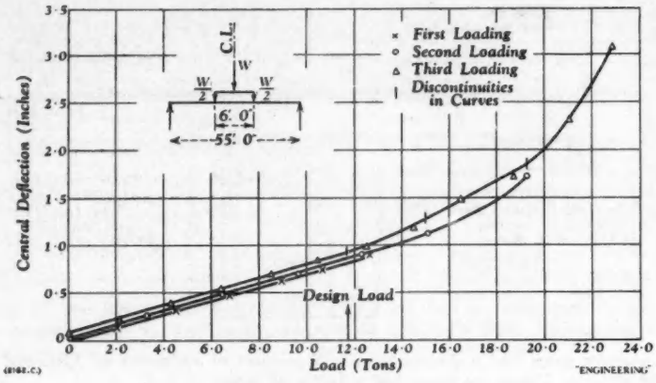


Fig. 3 Load-deflection curves for the beam. The curves demonstrate that, for short-time loading within the limits of the designed loading, the beam behaves elastically.

p = ratio of steel to the full beam section, 0·00465;

C_r = flexural compressive strength of the concrete; taken to be 0·79* of the cube strength, 6,800 lb. per sq. in.; and

d = depth of steel from top flange, 27·0 in.

The theoretical ultimate moment is thus found to be 11,450,000 lb.-in. which is within the expected 10 per cent. accuracy usually obtained.

Defining two safety factors by the following relationships,

$$S_L = \frac{M_{ult.} - M_D}{M_L}, \quad \text{and} \quad S_{L+D} = \frac{M_{ult.}}{M_L + M_D},$$

the test gives the following values for these factors: $S_L = 2{\cdot}4$ and $S_{L+D} = 2{\cdot}0$, which may be considered as satisfactory.

BEAM BEHAVIOUR

The relation between load and central deflection is shown in Fig. 3, herewith, where the results for the three loading cycles are plotted. The fact that the lines are parallel indicates that the differences between the loading cycles may be ascribed to bedding down of the beam supports and of the deflection gauge.

The almost perfect linearity of the first loading curve demonstrates the elastic behaviour of the prestressed beam when subject to short-term loading within its design conditions. The second loading curve shows linearity up to about 13·8 tons, where the effective stiffness of the beam begins to reduce progressively for increased bending moment, the tensile strength of the concrete having been exceeded and cracks formed. The third loading curve begins to show non-linearity at the design load, indicating that a zero tensile stress state exists in the bottom fibres and, as the load increases, the previously formed cracks start re-opening.

From the slope of the linear portion of the load-deflection curves the stiffness of the beam may be determined to be 14·55 tons per inch of central deflection. The support and load conditions and section properties lead simply to a value for an effective modulus of elasticity. The value so determined is $E = 5{\cdot}26 \times 10^6$ lb. per sq. in. which is in accordance with the results obtained from the control cubes.

CALCULATION OF TENSILE STRENGTH

Applying the results given in the Appendix to the load-deflection curve of the test gives a value of 2·1 tons for the load difference between zero tensile stress and cracking, which corresponds to a moment change of 690,000 lb.-in. The flexural tensile strength of the concrete calculated from this moment is only 290 lb. per sq. in., a result which is not consistent with the cube strength values. This low result may possibly have been due to the joint at the one-third point opening before the concrete had cracked at the span centre.

The applied moment at the point of onset of non-linearity in the second loading cycle appears to coincide with the design load moment of 3,885,000 lb.-in.

The expression derived in the Appendix for the value of the prestressing force, H, may be used to obtain its value; it is found to be 262,500 lb.

Thus the three bars, with a total area of 2·98 sq. in., were stressed to 39·3 tons per sq. in. under the full design moment and the concrete compressive stress found to be 1,920 lb. per sq. in.

With the assumption that the prestress remains unaltered with the reduction of load, the stresses in the "dead-load only" condition are readily calculated to be 280 lb. per sq. in. compression at the top and 1,560 lb. per sq. in. compression at the bottom.

Since the beam was supported at the time of prestressing in such a way that the operative dead-load moment was only 876,000 lb.-in., the change in strain at the steel level from prestressing to full dead load plus design live load was $2{\cdot}73 \times 10^{-4}$, which is equivalent to a stress of 3·5 tons per sq. in. From these figures it is found that the stress loss in the bars was 14·5 per cent. from the initial stress of 42 tons per sq. in.

STRAIN MEASUREMENTS

The strain readings taken during the test show good agreement with the results expected from the load-deflection curve. The compressive strains of the top gauge show similar departures from linearity at the same loads as in the load-deflection result. The readings from the middle gauge indicate that it was placed at the neutral axis for live loading and that it showed tensile strains as soon as cracks were formed, one occurring within the gauge length.

The bottom gauge showed the expected tensile strain increase with load in the linear range and a reduction of tensile strain with increased load beyond 14 tons due to two cracks opening on both sides of the gauge length.

The stress-strain readings have been plotted across the beam depth in Fig. 4, herewith, and show the strain states under various loads. It will be seen that under the working load of 11·7 tons the extreme fibre stress change, as determined from the strain gauge readings, is about 1,700 lb. per sq. in. which is in reasonable agreement with the values of 1,640 lb. per sq. in. and 1,560 lb. per sq. in. determined from the deflection curve.

CONCLUSIONS

The main conclusions from the test are as follows:

In the first loading cycle the beam behaved elastically up to 13·8 tons; later, when the tensile resistance of the concrete had been destroyed, the load of 11·7 tons, equivalent to the design moment, induced a zero tensile stress condition in the beam.

The ultimate live load carried by the beam was 27·9 tons corresponding to an ultimate total moment of 10,670,000 lb.-in. This was in reasonable agreement with the estimated value. Factors of safety on live load and total load, as defined above, gave values of 2·4 and 2·0 respectively.

The estimated flexural tensile strength of the concrete was 290 lb. per sq. in. which appeared low. This was attributed to the opening of the joint between the two parts of the beam.

An estimate of the prestressing force showed that the losses were 14·5 per cent.

The estimated stress conditions in the beam derived from the deflection results and the strain results gave consistent results.

The cracks that occurred at loadings well above the design range were well distributed, and subsequent inspection showed that the

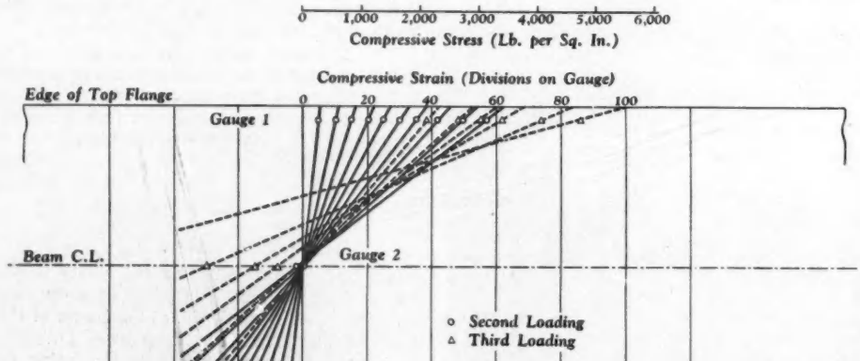


Fig. 4 The strain distribution across the depth of the beam for various loads. The rising neutral axis at high loads is caused by the change in the second moment of area as the section cracks.

* The cylinder : cube ratio of crushing strength has been taken as 0·93 and the flexural : cylinder ratio as 0·85. See R. H. Evans, "The Plastic Theories for the Ultimate Strength of Reinforced Concrete Beams," *Jl.I.C.E.*, vol. 21, pages 98 to 121, (1943); and C. S. Whitney, "Plastic Theory of Reinforced-concrete Design," *Proc. Am. Soc. Civil Engineers*, vol. 66, No. 10, pages 1749 to 1780, (1940).

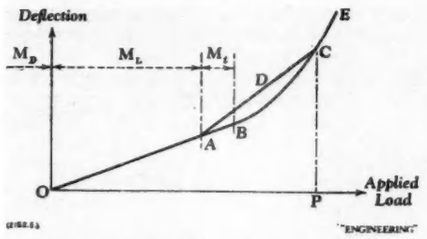


Fig. 5 Typical load-deflection curve for a prestressed-concrete beam.

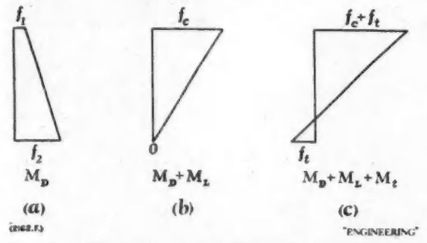


Fig. 6 The stress conditions of a prestressed-concrete beam in the three critical loading states.

grouting of the bars had been well performed. The beam failed by crushing of the concrete under one point of load application.

APPENDIX

The load-deflection curve of a prestressed beam generally takes the form shown in Fig. 5 where the first loading cycle, up to a load P, gives the curve OABC and a second loading cycle follows the curve OADCE.

The first point which becomes apparent is the change at B from the straight line OAB to the curve BC. This is attributable to the tensile strength of the concrete being exceeded at the lower extreme fibres, and cracks being formed which reduce the beam stiffness. The stress condition at B is that of Fig. 6 (*c*) where f_t is the flexural tensile strength of the concrete.

On a second load cycle the previously opened cracks re-open at A when the lowest extreme fibre stress exceeds zero, since the tensile resistance has previously been destroyed. The stress condition at A is that of Fig. 6 (*b*).

The load difference between the points A and B and the form of loading enable the moment M_t to be determined.

Since $\frac{M_t}{z} = f_t$ we may calculate directly the flexural tensile strength of the concrete.

When the beam is in the load condition at A we know, from Fig. 6 (*b*), that the centre of pressure of the prestress must be at the upper core limit which is $\frac{I}{A\,y_2}$ (where y_2 is the distance from the centroid to the bottom extreme fibre).

The effect of the applied moment $M_D + M_L$ has therefore been to displace the centre of pressure from the cable position, with eccentricity e, to $\frac{I}{A\,y_2}$. Thus we may write

$$\frac{M_D + M_L}{H} = e + \frac{I}{Ay_2},$$

or

$$H = \frac{M_D + M_L}{e + \frac{I}{A\,y_2}},$$

whence the prestress H may be calculated.

With a knowledge of the value of the prestress, the concrete stress f_c is found from $f_c = \frac{y_2 H}{dA}$, and the initial stresses f_1 and f_2 of Fig. 6 (*a*) are found by subtracting the stresses due to the moment M_L from the stresses of Fig. 6 (*b*).

COUNTING INTO BATCHES

EQUIPMENT FOR DIVIDING ARTICLES INTO GROUPS OF UP TO 1,000

In many industrial processes it is necessary to count various articles into batches, each batch consisting of a predetermined number of articles. It is also desirable that this should be done automatically and that there should be no counting error. Electronic equipment to do this has been developed by Ericsson Telephones, Limited, Beeston, Nottingham. When the last article of each batch has been counted, the batch should be removed automatically or the articles should be diverted into another channel.

The device described is electronic but, with one exception, uses cold cathode valves throughout. This type of valve has a much longer life than the normal thermionic type. The exception is a gas-filled tetrode which is operated only once per batch, and then in an on-off condition and in such a manner that very large changes in valve parameters cannot adversely affect its performance. The Ericsson counter is claimed to be relatively inexpensive and more flexible in application than existing equipments.

COUNTS 100 PER SECOND

The unit, as designed, provides for a maximum count of one thousand per batch, the desired number being chosen by the setting of three selector switches. The output signal obtained at the termination of a batch operates a set of relay contacts. Higher speeds of operation may be obtained by using the relay current pulse to operate directly an electro-magnetic shutter or other device. Normally the output takes the form of a current pulse or momentary operation of the contacts, but if desired, the output contacts may be held operated and released when required by removal of an earth connection. Similarly, resetting of the unit is normally automatic after the termination of a batch, but may be delayed and effected when a second connection is removed.

The maximum counting speed has been limited to a hundred per second, as the speed of operation of the external mechanisms generally prevents the counting rates exceeding this figure. It has been assumed that the input pulses will normally be obtained mechanically, by the operation of contacts, photo-electrically, by interruption of a light beam, or magnetically, by the inductance change in a search coil. The necessary power for such auxiliary apparatus has been provided and is brought out to a multi-contact socket.

Many detecting devices give rise to spurious pulses having a fixed time relation to the pulses to be counted. In order to prevent these from operating the counter, the input circuit may be "paralysed" for a known time within the range 5 to 500 milliseconds.

DEKATRON OPERATION

The basic counting circuit uses three selector-type dekatrons coupled in cascade by trigger triodes. With this type of dekatron it is possible to connect to any electrode individually, so that an output pulse may be obtained at a particular electrode or alternatively the position of the glow may be preset to any digit. In this application the latter facility is used in conjunction with the ability to cycle the glow in an anti-clockwise direction.

Considering a single digit counter, it can be seen that with the arrangement described above, an output signal will be obtained at 0 cathode after a number of impulses, equal to the number at which the glow was originally preset, have been applied to the counter. If a number of stages are to be used in cascade it is desirable that the output signal be obtained from a point on the highest order stage, whatever the order of the preselected number. Therefore, in the case quoted above, the output signal obtained at 0 cathode on the units stage must be passed through the successive stages to the output point. As these have previously been preset to digit 0, the coupling point between the units and tens stages must be 0 cathode, and between succeeding stages must be 9 cathode, the output point being 9 cathode of the highest order stage. Providing that the selected number is not divisible by 10^n where n is any whole number, the above arrangement will give correct results. If the number is divisible by 10^n the coupling between the units and tens stages, and n succeeding couplings must be taken from 0 cathode.

CIRCUIT DESCRIPTION

Two switches control the presetting of the glow position for the first dekatron, except for position 0 which has two independent switches. Four similar switches perform the same function for digits 1-8 of the tens and hundreds stages respectively and two more for digit 9 and 0.

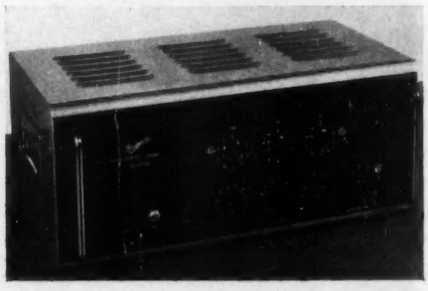
The couplings between the second and third dekatrons and between the third dekatron and the output thyratron are taken through other banks of the units and tens selector switches in such a way that the conditions for correct counting as stated above are obtained.

The couplings between the first and second, and second and third, dekatrons, use a conventional trigger-triode, dekatron-drive circuit, the connections being such as to cycle the glow anti-clockwise. The input circuit to the first dekatron consists of a bi-stable trigger-triode pair having a paralysis time controlled by a five-position switch covering the range 5 to 500 milliseconds. This enables the effect of spurious input pulses to be eliminated.

The output circuit consists of a thyratron, the anode circuit of which contains the reset relay RA and a connection to the output relay RB. In place of the latter may be connected the coil of an electro-magnetic shutter or other device particular to the application, provided that this coil has approximately the same characteristics as the coil of RB.

The coil of RA may be short circuited by connecting two terminals so that the unit only resets when this connection is broken externally, Emergency resetting is performed by operating RA from the high-tension supply by a push-button. If required RB may be held operated over its own contacts by connecting a terminal to earth. RB is then only released when this connection is broken.

The power unit is of conventional design providing in addition to the supplies for the unit itself, sufficient power to operate a photo-electro cell amplifier and a 6-volt, 36-watt light source. The whole equipment measures 19 in. by 8 in. by 7 in. and weighs 20 lb.



This batch counter will observe articles passing at a rate of 100 per second and will count them into groups of a selected number. It has a power supply output for a counting head as well as one for the dividing mechanism.

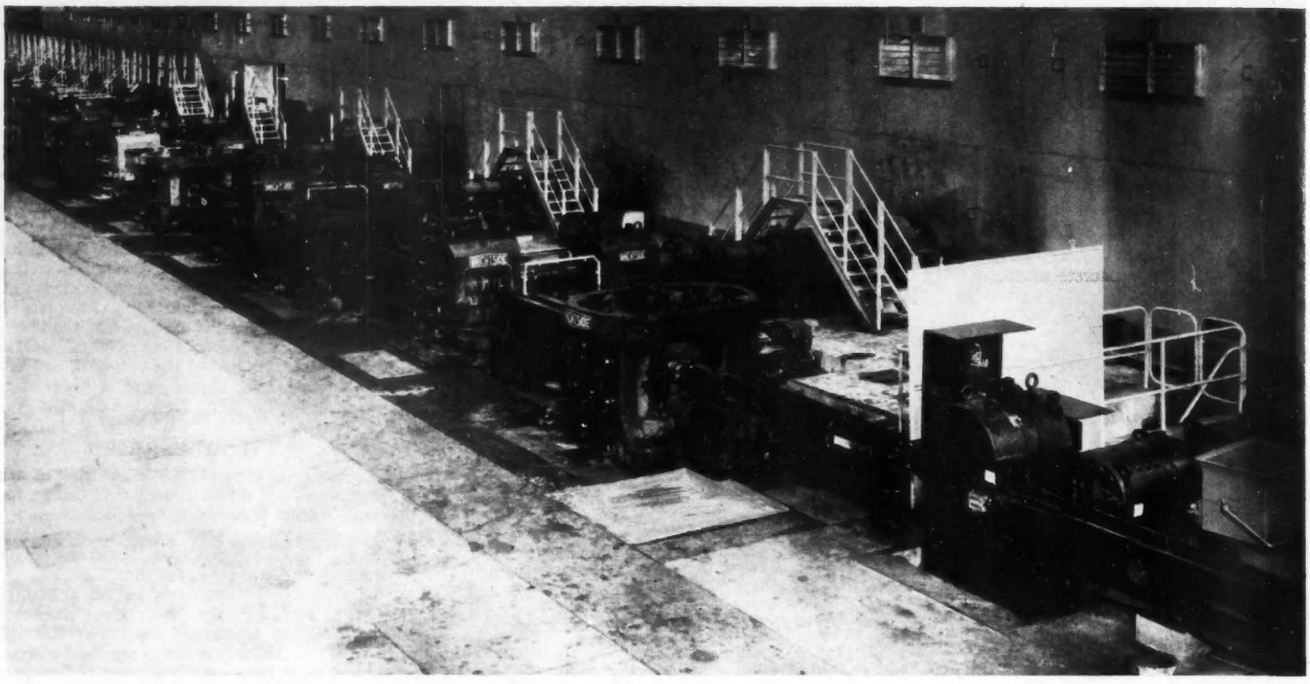


Fig. 1 Of the 17 stands in the 11-in. continuous rolling mill, eight, incorporating 600-h.p. motors, comprise the finishing train, seen here from the delivery end.

Fig. 2 The oil-fired continuous reheating furnaces with run-out and mill-approach equipment. The furnaces are side charged and discharged.

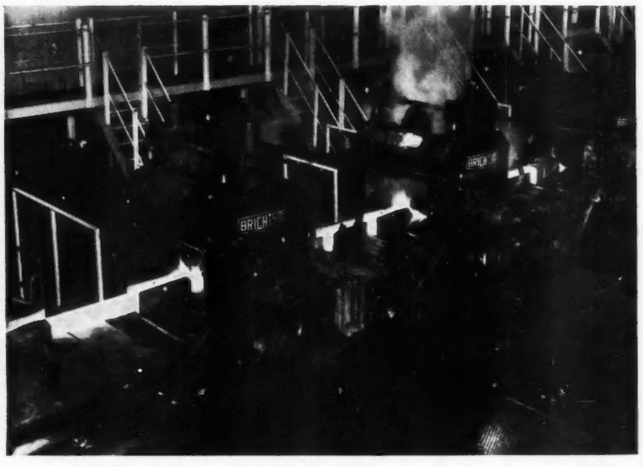


Fig. 3 Three of the five roughing-roll stands. The 16-in. rolls are driven by motors ranging in horse-power from 125 to 400.

Fig. 4 From the flying dividing shear, straight bars go to this mechanical cooling bank, which is 255 ft. in length.

Fig. 5 The cold gang shear illustrated here has a blade load of 250 tons, operates at 25 strokes a minute and can cut twelve 1-in. bars each stroke.

PARK GATE IRON AND STEEL COMPANY

11-IN. CONTINUOUS BAR ROLLING MILL

In order to satisfy an increasing demand for small rounds, hexagons, squares, and flats ranging in size from ⅜ in. to 1¼ in., rolled to a close tolerance and having a good surface finish, the Park Gate Iron and Steel Company, Limited, Park Gate Works, Rotherham, have installed an 11-in. continuous rolling mill, comprising 17 stands, on a site at Roundwood, which lies to the north of the present works and alongside the main railway line from Sheffield to Leeds. The rolling mill plant was developed and arranged by the Brightside Foundry and Engineering Company, Limited, Sheffield, who designed, manufactured and obtained all the mechanical and electrical equipment, working in close collaboration with the technical staff of the owners. The building and civil engineering work was carried out to the designs, and under the direction, of Bylander and Waddell, London.

ROLLING-MILL BUILDING

The site occupies an area of 200 acres and the levelling work necessitated the moving of 600,000 tons of soil, sub-soil and rock. As may be seen in the plan in Fig. 6, the mill building is T-shaped and covers an area of 253,750 sq. ft. It houses, in addition to the rolling mill, two loading bays, a billet and a coiling bay, and electrical- and mechanical-maintenance and roll shops. The central bay which houses the furnaces, rolling mill and a cooling bank is 900 ft. long and has a crane span of 90 ft. Along one side of this is the west bay, 1,000 ft. in length and having a crane span of 50 ft., in which are stored steel billets and coils of finished material. Along the other side of the central bay is the east bay, 400 ft. in length and also having a crane span of 50 ft., in which are housed the maintenance shops, comprising the fitting, electric and other shops and the roll-turning shop. Two shops of equal area both 500 ft. long and 80 ft. wide, constitute the head of the letter-T; the north No. 1 shop is used for the storage and dispatch of material in the form of coils and straight bars and the north No. 2 shop for the storage and dispatch of bar material alone.

The central rolling-mill bay is served by a 25-ton crane furnished with a 5-ton auxiliary hoist. The billet bay and the finished-coils bay are both served by 10-ton cranes, the latter, however, having a coil-handling hook. Installed in the maintenance shops is a 5-ton crane, while the two north bays are served by two 10-ton cranes for bar handling only and one 10-ton crane adapted for handling bars and coils.

The mill building is of the vertical north-light type and the height from floor level to the crane-gantry rail is 26 ft., and to the apex of the roof 51 ft. The walls are constructed of 9-in. brick up to a height of 10 ft. above the mill-floor level; above this are 8 ft. of glazing and the remainder of the wall is made up of galvanised sheets of the "Scandinavian" type. The roof is constructed of sheeting produced by the Robertson Building Service and vertical glazing is provided. Artificial lighting is furnished by a blend of mercury-vapour and tungsten lamps.

BILLET-REHEATING FURNACES

Billets to feed the new rolling mill are transferred from the company's cogging mill at Park Gate Works, about a mile from the 11-in. mill, by two 20-ton heavy-duty tractors and seven trailers, each having a carrying capacity of 20 tons. The billets are in two sizes, namely, 4-in. square by 18 ft. long, weighing 958 lb. each, from which are rolled round bars from 1¼ in. to ⅝ in. diameter inclusive, or their equivalent solid section, and 3-in. square by 18 ft. long, weighing 540 lb. each, from which will be rolled round bars from 1⅛ in. to ⅜ in. in diameter or their equivalent solid section. The billets are stocked in the 50-ft. billet-storing bay until required. They are heated to the hot-rolling temperature in two oil-fired continuous reheating furnaces, supplied by Stein and Atkinson Limited, and seen in the plan, Fig. 6, and also shown in Fig. 2. These furnaces are fitted with Newton metallic air recuperators and are side charged and side discharged. The billets are lifted by a crane on to a charging table and then either skidded or rolled over on to a non-driven roller table. A motor-driven double charging head pushes a maximum of four billets through the side-charging door into either of the furnaces.

The length of the interior brickwork of each furnace is 65 ft. 4 in., the width 20 ft., and the length of the soaking zone 19 ft. The furnaces are each capable of heating a maximum of 35 tons of billets per hour, this being equivalent to discharging a billet from each furnace every 46 seconds. The oil used for firing the furnaces is atomised by compressed air at a pressure of 35 lb. per square inch. For this purpose three air compressors are installed in the oil-fuel pump house – two of them being in use with one as a standby; steam is also available as a standby. There are two firing zones in the furnaces; the first or heating zone having ten burners and the second or soaking zone having eight burners. The hot billets are side-discharged on to a roller table running between the two furnaces. From this they are skidded on to the mill approach tables. The charging and discharging operations of the billets are under the observation and control of an operator standing in a pulpit. Temperature recorders, oil and air-flow recorders, draught indicators in the waste-gas flues and other instruments in the furnace-control system are placed in an instrument house, each furnace being furnished with its own panel.

ROLLING-MILL INSTALLATION

As stated in the introduction, the mill consists of 17 continuous stands; five of them comprise 16-in. roughing-roll stands, four 12-in. intermediate-roll stands and eight 11-in. finishing-roll stands. On the finishing train each alternate pair of rolls is vertical, the last pair, that in stand No. 17 being vertical. Each stand has its own motor, the 16-in. roughing rolls, three of which are seen in Fig. 3, having motors of 125, 175, 225, 300 and 400 h.p., respectively. The 12-in. intermediate rolls, at stands Nos. 6 and 7, are

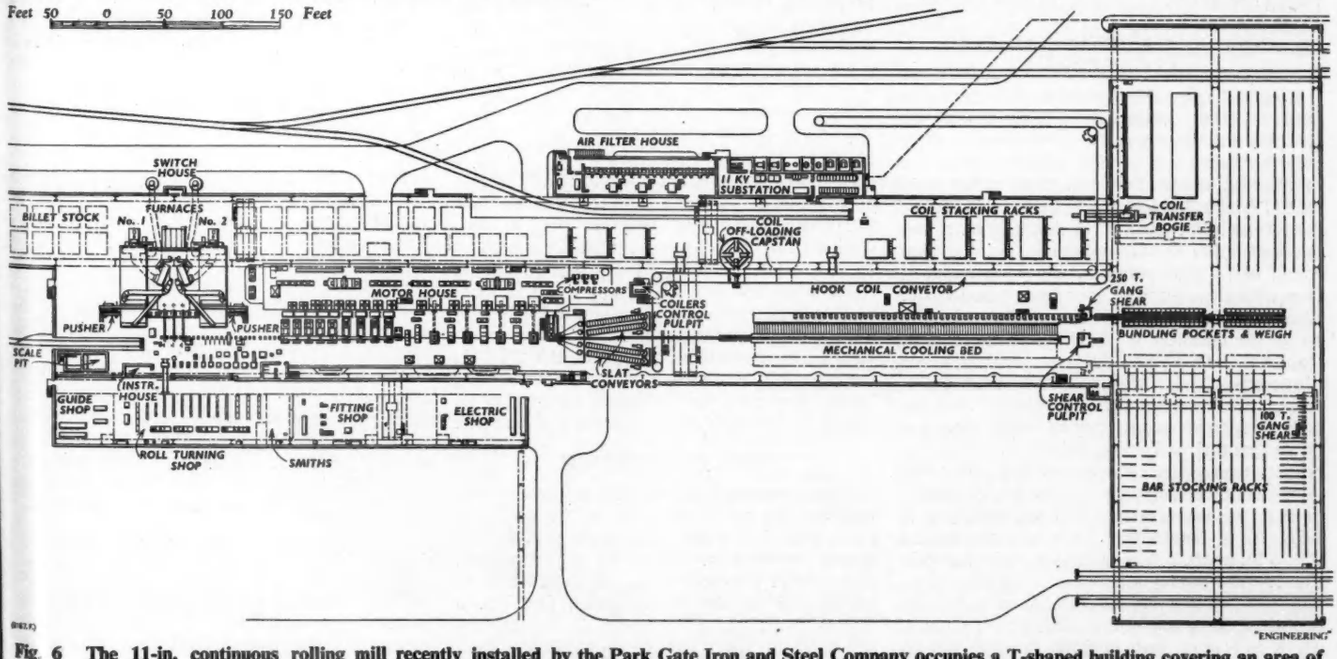


Fig. 6 The 11-in. continuous rolling mill recently installed by the Park Gate Iron and Steel Company occupies a T-shaped building covering an area of 253,750 sq. ft., which also houses loading bays, billet and coiling bays, roll shops and maintenance shops.

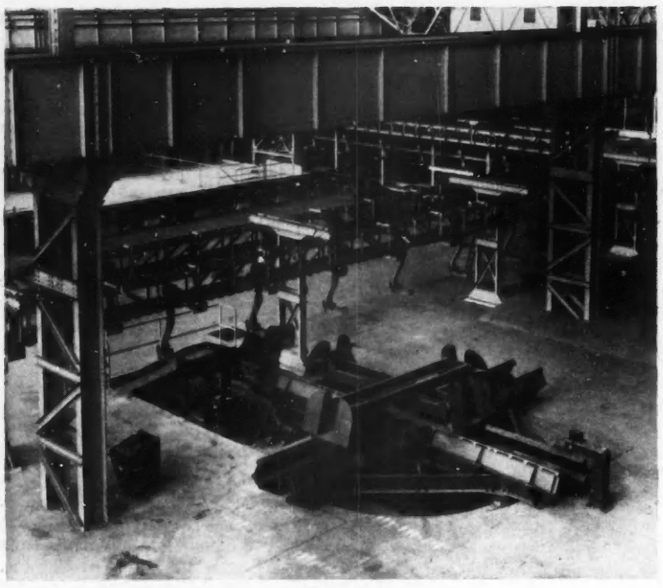


Fig. 7 The hook conveyor shown here is 1,672 ft. in length and carries coils from the slat conveyor to the four-arm coil-receiving stand, which is also illustrated. The conveyor, which operates on a "start-and-stop" system, assists in the cooling of the coils.

each of 500-h.p., and at stands Nos. 8 and 9, each 600 h.p. All the eight 11-in. finishing rolls are driven by 600-h.p. motors. The main mill motors have been supplied by the English Electric Company, Limited. A general view of the finishing train, from the delivery end, is shown in Fig. 1. The outputs of the mill range from 12·4 tons per hour when rolling ⅜-in. bars to 65 tons per hour when rolling ⅞-in. to 1¼-in. sizes.

A flying crop shear operates between Nos. 9 and 10 stands, namely, before the bar enters the finishing section of the mill. This crops and trims the ends of the bars before they enter the 11-in. finishing rolls. The bearings of the 16-in. and 12-in. rolls are of fabric material lubricated with clean water and the 11-in. finishing-mill rolls are fitted with roller bearings. The "oval-round-oval-round" method of reduction is employed, and roller guides are employed to enter the oval-section bars into the vertical roll stands, Nos. 11, 13, 15 and 17. The control pulpits are arranged alongside the mill from which the operators have an excellent view of the rolling operations.

COILING MACHINES AND COIL CONVEYORS

Four coiling machines, of the "pouring" type are provided immediately following the last (No. 17) finishing stand, from which material for coiling emerges at a speed of 2,750 ft. per minute in the case of ⅜-in. round material, 2,700 ft. in that of ½-in. and-⅝ in. rounds, 2,050 ft. in that of ¾-in. round bar, 1,845 ft. in that of ⅞-in. round bar and 1,400 ft. per minute in that of 1-in. round bar. The coiling machines are designed to produce two sizes of coils from ⅜-in. to 1-in. diameter rolled material. The smaller coils have an inside diameter of 27 in. and an outside diameter of 39 in., and the larger coils an inside diameter of 39 in. and an outside diameter of 54 in. The completed coils are ejected from the coilers on to slat conveyors of which there are four in parallel, each being 50 ft. long. From the slat conveyors the coils are loaded on to the hook cooling conveyor, travelling at right angles to the slat conveyors. The hook conveyor is 1,672 ft. in length and its hooks are spaced 7 ft. 6 in. apart. A general view of it is seen in Fig. 7. The conveyor is operated on the "start-and-stop" system and the coils are unloaded and deposited on to a four-arm coil-receiving stand, which is rotated into position for the pick-up hook on the 10-ton overhead crane. The crane conveys the coils to the weighing machine and thence to the coil-stacking areas.

COOLING BANK FOR STRAIGHT PRODUCTS

Straight bars leave the finishing rolls at speeds of 1,600 ft. per minute in the case of ⅜-in., ½-in., ⅝-in. and ¾-in. rounds, 1,500 ft. in that of ⅞-in. products, 1,146 ft. in that of 1-in. rounds, 903 ft. in that of 1¼-in. products and 733 ft. per minute in that of 1½-in. rounds. After passing through a flying dividing shear the bars go to a mechanical cooling bank, a general view of which is seen in Fig. 4. The cooling bank is 255 ft. in length. Each roller of the ingoing table is driven by a separate motor but the speed of the bar is arrested by cast-iron lifting apron plates situated between each roller on the table. From the ingoing roller table the bars are ejected into the first of two straightening pockets. When the bars are ejected from the second straightening pocket they are placed on to carry-over bars designed to convey them either in notches or on the flat. Thence they are deposited on to shuffle racks which collect the cooled bars and deliver them to the outgoing roller tables. These feed the bars to a 250-ton cold gang shear seen in Fig. 5. The distance between the centre of the ingoing roller tables and the centre of the outgoing roller tables is 21 ft. 6 in. The cold shear is driven by a 40-h.p. motor and has a blade load of 250 tons operated at 25 strokes a minute. The machine will shear twelve 1-in. diameter bars at each stroke. The sheared bars, which range from 15 ft. to 50 ft. in length, are discharged from the roller tables by means of a series of chain unloaders into bundling pockets connected to self-indicating weighbridges situated in the north bays in the horizontal portion of the "T" in the plan, Fig. 6. The operation of the cooling bank is under the observation and control of an operator in a pulpit at the shears end of the bank.

MILL LUBRICATION

Three separate oil circulating systems are provided for the lubrication of the reduction gears, mill pinions and other equipment. No. 1 system covers Nos. 1 to 9 of the rolling-mill stands; No. 2 system, Nos. 10, 12, 14 and 16 stands and the first flying shear; and No. 3 system, Nos. 11, 13, 15 and 17 stands, the second flying shear and the four coilers. Each of the three systems comprises storage tanks, strainers, coolers, flow indicators and displacement pumps with stand-by units, all located in a basement alongside the rolling mill. Oil supplies are pumped direct from tank vehicles through openings in the mill-shop floor into storage tanks.

ELECTRICITY SUPPLY

Electricity for the new plant is supplied by the British Electricity Authority from the "grid." The Yorkshire Electricity Board have built a substation adjacent to the building to which power is brought at 66 kV. The supply is transformed through two 15,000-kVA transformers for distribution to the rolling-mill substation. Electricity is distributed from this substation at 11 kV for the main motor-generator drives, at 415 volts three-phase for the auxiliaries, at 240/415 volts for lighting, and at 440 volts direct current for the cranes. The rolling-mill motors, motor-generator sets, booster sets and other plant are housed in a separate dust-proof building situated within the main mill building. This motor house has a detachable roof and sides to allow access by the 25-ton crane of the central 90-ft. bay. Cooling air is supplied to the motor house by three fans, each rated at 80,000 cub. ft. per minute at a pressure of 5 in. water gauge.

WATER SUPPLY

The quantity of water required for cooling the roll bearings and roll barrels, for lubricating the fabric bearings in the roughing and intermediate stands, for air compressors and high-pressure descaling pumps and for the oil-cooling systems, amounts to from 80,000 to 100,000 gallons per hour. The average rise in temperature, above normal, is of the order of 30 deg. F., and the losses due to evaporation amount to 10 per cent. of the total. This is equivalent to 8,000 to 10,000 gallons per hour and in order to avoid over-concentration of solids in solution there is a continuous bleed-off of 10 per cent. The bleed-off plus the loss by evaporation amounts to from 16,000 to 20,000 gallons per hour. Make-up water is taken from an outlying canal while contaminated water from the mill flows by gravity into a settling pit. The mill scale is removed by a grab operated from the shop overhead crane and is loaded into railway wagons to be returned to the Park Gate Works. The water is then pumped from the settling pit to a water-treatment plant supplied by Filtrators Limited. In this the make-up water and the water returned from the mill is dosed with lime and chalk to revive the temporary hardness, filtered and finally passed through an induced-draught cooling tower where its temperature is reduced some 30 deg. F. The tower, supplied by the Davenport Engineering Company, Limited, has a capacity of 100,000 gallons an hour, its dimensions being 42 ft. 7 in. by 22 ft., by 30 ft. high from the sill level. From the base of the tower which holds 36,000 gallons the cooled water is pumped to an overhead treated water tank, holding 50,000 gallons, for recirculation to the mill. The tank has been supplied by Horseley Bridge and Thos. Piggott, Limited. High-pressure water for scale cleaning is provided from a pump furnished with a 300-h.p. motor delivering 150 gallons of water per minute at a pressure of 1,000 lb. per square inch. There are two of these pumps, one being held in reserve.

STEAM FOR SPACE HEATING

The maintenance shops and offices are warmed by means of steam panel heaters. The steam is generated in two Dodman single-return economic boilers fired with fuel oil atomised by low-pressure air, with steam as an alternative

atomiser. The boilers are each 8 ft. in diameter by 14 ft. long over the tubeplates and comprise 88 tubes, each having an outside diameter of 3 in. The two fire tubes are each 2 ft. 9½ in. in diameter. The rated evaporative capacity of each boiler is 6,000 lb. per hour and they operate at a pressure of 100 lb. per square inch. The boiler plant is furnished with electrically-driven oil-circulating pumps, steam oil heaters (with an electric oil heater as a stand-by), steam-driven feed-water pumps and water storage and hot well tanks.

The equipment of the maintenance shops in the east bay includes two lathes having 11-in. centres for turning finishing rolls; one lathe of 12-in. centres for accommodating intermediate rolls; and one lathe having 16-in. centres for roughing rolls. The 12-in. and 16-in. centre lathes have also a set of carriages for turning, finishing and intermediate rolls, respectively. All three of these lathes are installed in the roll-turning shop. Other machine tools are installed in the fitting shop, electric shop and pipe-fitters' shop.

PNEUMATIC VALVES AND CYLINDERS FOR INDUSTRIAL USE

EASILY MAINTAINED EQUIPMENT DESIGNED TO WITHSTAND ABUSE

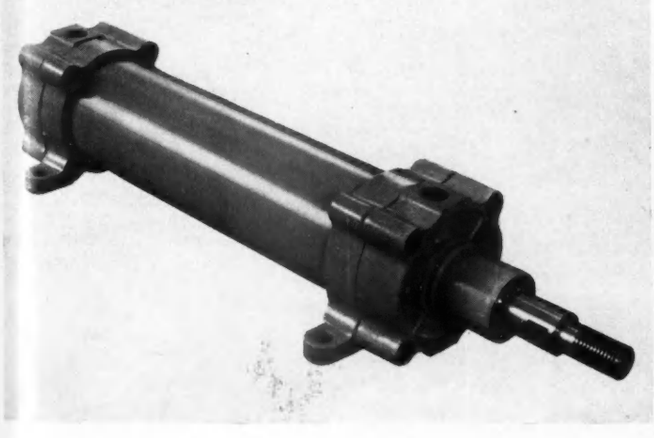
During the past two years a new range of compressed air cylinders and directional control valves for rugged industrial use has been undergoing intensive development by the Pneumatics Division of the Baldwin Instrument Company Limited, Brooklands Works, Dartford, Kent, and is now available commercially. This new general-purpose pneumatic equipment is built up from combinations of a number of interchangeable standard units – a system that offers advantages for use in extensive and diverse pneumatic installations in that the spares holdings can be minimised. The company's compressed-air equipment has been designed to withstand rough usage, to resist corrosion and to require the minimum of maintenance by unskilled labour without special tools; it is therefore well suited to building contractors' applications as well as to use in factory and maintenance shops.

All the equipment is designed for a maximum air pressure of 150 lb. per sq. in. The cylinders are available in six bore sizes ranging from 1½ in. to 8 in., with corresponding load capacities of 177 lb. to 5,000 lb. at a normal working pressure of 100 lb. per sq. in. The length of the stroke is made to suit customers' requirements. In addition to the single piston-rod type of cylinder shown in the accompanying illustration, standard cylinders can also be supplied with a two-bearing piston rod passing completely through the axis of the cylinder and emerging through both end covers – an advantage in installations where there is an appreciable bending moment on the rod.

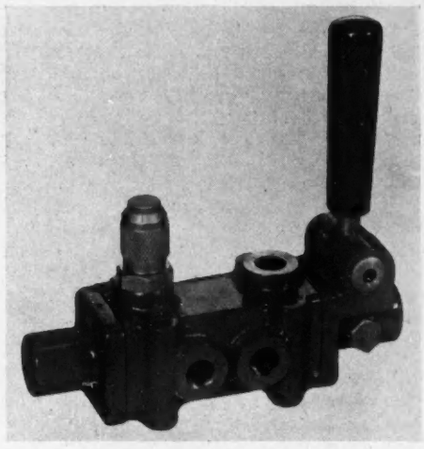
The cylinder can be supplied as a basic unit, or with a foot mounting as illustrated below, front or rear pedestal mountings, or front, rear and centre trunnion mountings; any of these mountings can be used in combination at any desired angle to one another. Once the cylinder is set up and the mounting is fixed to its base, there is no need for re-alignment after maintenance work; to inspect the working parts and to change the seals, which are of oil- and water-resisting synthetic rubber and are self-adjusting for wear, it is only necessary to remove the end covers and to withdraw the piston and rod assembly. It is also possible to re-orientate the inlet and outlet ports on site, to facilitate piping layouts, simply by rotating the cylinder end covers after removing the four attachment screws.

SYNTHETIC RUBBER NON-RETURN VALVE FORMS CUSHION

In order to take full advantage of the high reciprocating speeds possible with compressed air, all these cylinders are available with cushioning at either or both ends of the stroke. The arrangement of the cushioning feature is simple, and has been proved to be consistently efficient during extensive tests. It consists of a floating synthetic-rubber sealing cap in the end cover which acts as a non-return valve. As the piston enters the end cover on its forward stroke, it blocks the main air outlet so that the air pushed forward by the piston is compressed and can escape only through a small adjustable orifice in the seal. On the return stroke, air entering the main orifice lifts the sealing cap and is thus enabled to enter the cylinder. This form of cushioning remains effective even when the piston is badly misaligned as a result of long wear. The synthetic rubber seal, which is bonded to a stiffening ring, can easily be replaced by removing a circlip which retains it in the end housing.



This pneumatic cylinder is of a standard unit construction, available in six sizes from 1½ in. to 8 in. bore. All units are designed to withstand corrosion. The end covers and piston head are of Sherardised malleable cast iron, the cylinder bore is hard-chromium-plated, and the piston rod is of ground and polished stainless steel. The design provides cushioning at each end of the stroke.



Typical Baldwin manually-controlled valve, available with three-way or four-way connections in ⅛ in., ¼ in. and ½ in. bore sizes, also corrosion-proofed and of standard unit construction. The example shown is fitted with an adjustable speed regulator in the exhaust port to control the operating speed of the cylinder.

ANTI-CORROSIVE TREATMENT

For strength and wear, ferrous materials have been adopted for all the units. The end cover and piston head are of malleable cast iron, protected against corrosion by a zinc-diffusion process. The cylinder barrel is of precision-drawn steel, with hard-chromium-plated and polished bores to ensure freedom from corrosion by suspended moisture in the air supply, and to provide a hard highly-finished surface to withstand wear by the piston head and to prolong the life of the seals. The piston rod is of precision-ground and polished stainless steel, and is fitted with a tough synthetic-rubber wiper ring to ensure that no grit enters the bearing. The latter is of the oil-retaining sintered-bronze type.

CONTROL VALVES

Directional control valves are available in ¼ in. and ½ in. bore sizes with three-way or four-way connections, built up from standard body units, end fittings and operating mechanisms. The body and end fittings are robust corrosion-proofed malleable iron castings. The valve element is a profiled stainless steel spool, highly polished to reduce friction. It slides through the bores of a series of specially-formed oil- and water-resistant seals, which are effective in both static and dynamic states. Endurance tests on these seals have indicated an average life expectancy of the order of 10 million cycles. As in the cylinders, all working parts are readily accessible for servicing without disconnecting the pipelines or removing the valve body.

The valve shown in the illustration above is fitted with a standard hand-lever operating mechanism and is provided with an adjustable speed regulator on the exhaust port for controlling the piston speed. Other types of standard operating mechanism available include single or twin pedal operation, cam-operation, pneumatic pilot-operation, or single or double solenoid operation. Both spring-return and multiple-position indexed valves are available, as are also sequence valves and push-button-operated valves.

Among the applications which Baldwin pneumatic equipment has already served may be mentioned power-press operation, mechanical handling installations, cement-mixing plant, etc.

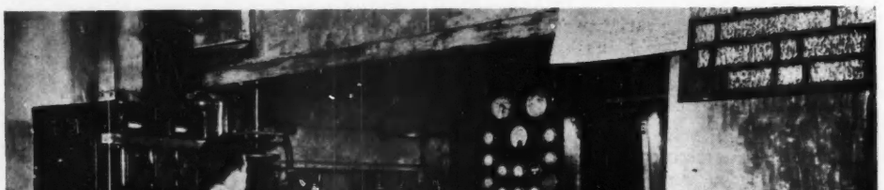


Fig. 7 Drum coiling rolled aluminium strip from the three-stand tandem cold mill.

Falkirk Works of the British Aluminium Company Limited (*concluded from page* 758)

PRODUCTION OF ALUMINIUM PLATE AND SHEET

2—POST-WAR DEVELOPMENTS

The core of the post-war developments at the Falkirk works was additional cold-rolling capacity, and two further strip mills, both of Davy and United Engineering manufacture, were installed in a new building on the north side of the original stage 1 works. These mills are a 15 in. and 38 in. by 44 in. four-high, three-stand unit, and a single-stand, four-high temper mill of the same size. The layout also incorporates a bulk-transport charger serving the mills and the associated annealing furnaces, and capable of handling material from the stage 1 section of the works.

The three-stand tandem unit, which is known as number six mill, was designed to deal with material prepared on number one roughing mill, the range of sizes accepted by the unit being from 0·036 in. to 0·120 in. thick, and 15 in. to 38 in. wide. The finished thicknesses produced by the mill range from 0·008 in. to 0·048 in. Fig. 7 shows the drum coiling of strip from this mill. Coils weighing up to 30 cwt. are paid off from a cone decoiler equipped with mechanical brakes and this is integral with an eleven-roll fully-tucking entry bridle, with hydraulic sticker action. The second and third mill stands are also equipped with entry bridles. Strip leaving the mill is coiled on an 18 in. diameter Klein reel, Fig. 8, having interlocking segments without a drum grip, the reel being fitted with a belt wrapper. The drum is designed to coil strip direct, but there is an alternative arrangement whereby thin-gauge strip can be coiled on mild-steel spools for subsequent annealing and temper rolling. The stands are spaced at 12 ft. centres, and each is driven by a 500-h.p. motor giving a maximum delivery speed of 850 ft. per minute. Interstand strip tensiometers are provided to measure strip tension up to 20,000 lb. with an accuracy within ± 2 per cent., and flying micrometers are fitted to each of the three stands. Typical reductions on common alloy are from 0·075 in. to 0·017 in., or 0·114 in. to 0·040 in.

The motor driving each stand is of 0/500/500 h.p. at 0/410/920 r.p.m., the current being supplied from a Ward-Leonard motor-generator set driven by a slip-ring induction motor of 1,800 h.p., with two variable-voltage direct-current generators of 625 kW each. The reel motor is 0/195/195 h.p. at 0/470/1,200 r.p.m., and is supplied via a reel booster, drum tension up to a maximum of 10,000 lb. being regulated by a Magna-volt tension-control exciter. The main drive motors are coupled through graded reduction gears having integral top-roll drive pinions. The nominal output speeds are 232/519 ft. per minute on the first stand, 306/687 on the second, and 355/795 on the third. Field weakening to the permissible limit enables maximum third stand rolling speeds of between 850 and 900 ft. per minute to be attained.

BATCH MOVEMENT OF COILS

Coils are conveyed in 10/15 ton batches on a Wellman Smith Owen charger, Fig. 9, which operates on a right-angled track running north and south to serve a line of annealing furnaces, and then, by means of a power-driven turntable, turns to run east and west alongside the mill-loading tables. The coils are lifted individually by automatic tong-type grips, and loaded on to a coil down-ender, from which the coils descend a gravity V-track, at the lower end of which they are checked by an automatic braking device. From this point coils are released automatically one at a time by push-button control, and travel forwards on to a coil carriage and to a tailing station. At this point a tail is pulled out from the coil by a half-drum tailing machine sunk below the level of the coil-carriage track. The coil is then traversed over the tailing machine and the tail is entered into a roller leveller which draws out the tail and flattens it, while an up-cut shear located beyond the leveller is used to trim and square the coil end. On reversal of the leveller the coil is thrust towards the mill, the tail is thrown over manually, and the coil rolls on to a slat conveyor, where a line of tailed coils is marshalled ready for charging into the mill pay-off stand. A hydraulically-operated jack carriage receives each coil from the slat conveyor, transfers it between the decoiler cones and automatically centres it for correct height; the cones are then closed on the coil, and mill threading and rolling proceed. The finished coil is ejected from the drum and passes to an up-ender. It is then lifted by crane and a charge is marshalled for handling by the bulk transporter.

Number seven mill, which is a 15 in. and 38 in. by 44 in. four-high, single-stand unit, is used for temper rolling. It is generally similar to the third stand of the three-stand mill which is known as number six. The mill is equipped with a cone decoiler and an eleven-roll entry bridle. There is an 18 in. diameter Klein reel and belt wrapper on the delivery side, as is the case with number six mill, and the equipment for coil handling to and from the mill is also identical with that provided for number six. The main drive and drum drive equipment are the same as that used on number six mill; the complete electrical equipment on both mills was supplied by the English Electric Company Limited. Conveyor equipment is provided for the circulation of empty spools between the entry and delivery sides of number seven mill, and also between the pay-off stand of number seven mill where empty spools collect, and the coiling stand on number six mill where they may be required.

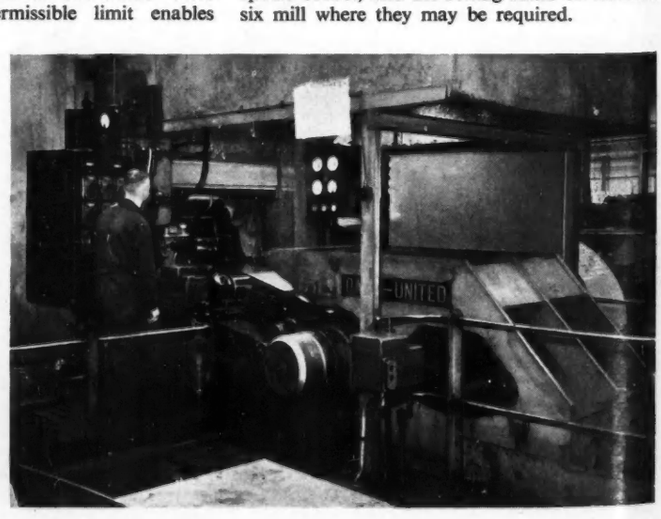


Fig. 8 Coiling finish-rolled strip from the single-stand temper mill on a Klein reel and belt wrapper.

ANNEALING EQUIPMENT AVAILABLE FOR BOTH SECTIONS OF THE WORKS

The annealing plant in the stage 2 section of the works is served by the transporter line running north and south, and can thus receive part-rolled coils from stage 1 mills for annealing and finish-rolling in stage 2; or it can be used for intermediate annealing of material being rolled in the stage 2 mills. The finished width of strip rolled in the stage 2 section is limited to 3 ft., but 50 per cent. of the annealing capacity is suitable for coils up to 6 ft. wide, and it can thus be used to augment the annealing arrangements of the stage 1 section of the works. The annealing plant is of G. W. B. and McDonald Furnaces manufacture, and consists of two double-chamber batch-type electric furnaces, each of which has two forced air-circulation cooling chambers alongside. One furnace unit has heating chambers 18 ft. long by 9 ft. wide, and will accommodate up-ended coils of a maximum width of 54 in. It is rated at 450 kW per chamber. The second furnace has a similar hearth size, but is rated at 550 kW per chamber, and will take coils 78 in. wide. Both furnaces have external heating elements, and high-speed air-circulation equipment. The cooling chambers are also provided with forced air-circulation, and are capable of cooling a furnace charge from the annealing temperature of around 450 deg. C. to approximately 100 deg. C. in the cycle time for the succeeding charge, that is, six to eight hours, according to coil-wall thickness.

Drum-wound coils for annealing are arranged on the charge tables with their axes vertical, and are handled by the 15-ton charger in this position, but thin gauge coils, such as foil stock at 0·018 in. thick, which are mill wound on steel spools, are supported on steel racks with their axes horizontal. These coils are carried by the projecting spool ends, and ten or twelve coils, each nearly a ton in weight, can be handled as a single furnace load; alternatively, up to about 20 coils of smaller weight can be accommodated.

PROCESSING COILED STRIP

The plant installed in conjunction with the stage 2 mills is designed to process coiled strip either as cut sheets or as trimmed and re-wound coils. There are two trimming and re-winding lines, one of which is designed for pull-through trimming only on strip from 0·010 in. to 0·036 in. thick and of 36 in. maximum width. The strip is paid off from a cone decoiler, which will accept either drum or spool-wound coils, and re-winding is carried out on a stand with driven chuck plates designed for steel spools only. The second trimmer line is equipped with dual pull-through and driven trimmers to handle strip up to 42 in. wide and 0·064 in. thick. Re-winding is carried out on interchangeable collapsing drums giving a range of coil bores from 5 in. to 16 in. diameter, or greater if required. Both lines are fitted with scrap-disposal equipment, and the speeds are moderate in order to facilitate coil inspection. For the production of flat sheets from coiled strip there is a trimming, flattening, and shearing line including a Hallden flying shear. The line is equipped with an automatic air-blown stacker for sheets up to 5 ft. long. The cone decoiling stand will accept coils weighing up to 30 cwt., and strip ranging in widths from 15 in. to 38 in. and thicknesses from 0·008 in. to 0·048 in. can be accommodated. The line operates at up to 350 ft. per minute, and will cut sheets to a maximum length of 12 ft. Coiled strip down to 0·008 in. thick can also be slit into narrow ribbon on a pull-through slitting machine, with twin-drum coilers.

Flat sheets up to 12 ft. long leaving the trimming and shearing line can be processed through one of two rotary corrugating machines made by the Streine Tool and Manufacturing Company New Bremen, Ohio. These machines, one of which is shown in Fig. 10, have hexagonal roll barrels to which are secured die segments, one set of segments extending around half the periphery of each roll. A machine can therefore be equipped to corrugate a 3-in. standard profile over half the roll periphery, while the other half may be tooled for a trough section. To change from one profile to the other it is only necessary to adjust the sheet feed mechanism, which takes very little time. Sheets are corrugated singly or in packs of two according to gauge. Operating in conjunction with the Streine corrugating machines, is a British Clearing 300-ton folding press, having a beam length of 18 ft. and 16 ft. between the housings. This machine is used for forming special roofing sections, longer lengths of corrugated sheet than the rotary machines can produce, or a wide range of general press work.

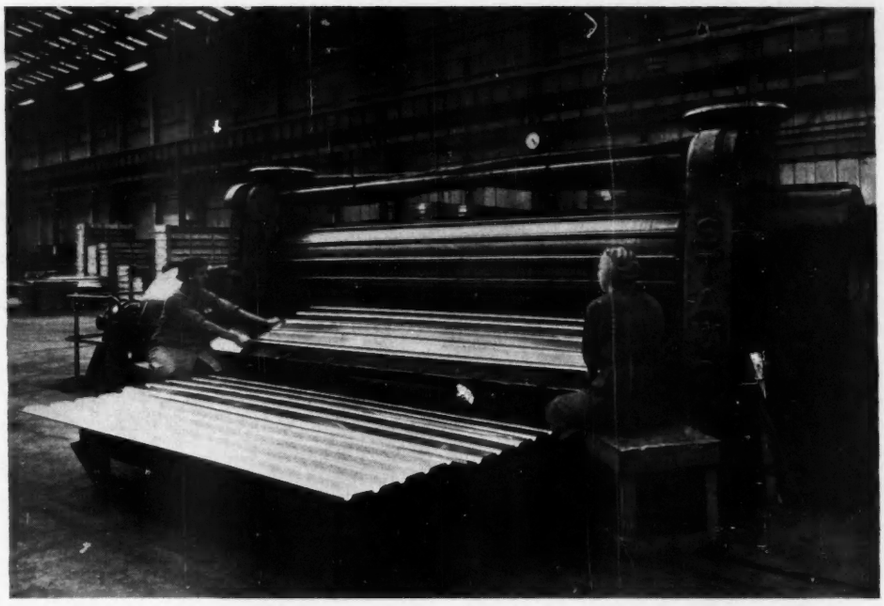


Fig. 10 Two sets of dies can be set up together in this roller corrugating machine. Changing from one to the other requires only an alteration of the sheet-feed mechanism.

Sheets can also be given an embossed surface by means of an embossing machine equipped with hardened and cambered precision-matched rolls, which are hydraulically loaded. Sheets between 0·020 in. and 0·048 in. thick and up to 48 in. wide can be dealt with by this machine, the speed range being from 78 ft. to 628 ft. per minute. The machine is at present used only for sheet processing, but modifications are now in hand to enable it to deal with strip.

Circles and other flat blanks are produced in a Rhodes 50-ton automatic blanking press, which can be operated at speeds ranging between 50 and 150 strokes per minute. It operates on strip up to 20 in. wide, by single or multiple punching, and is capable of a maximum forward feed of 12 in. per stroke. The strip is fed to the machine from a driven coil pay-off stand. Scrap disposal, blank removal, and blank stacking are mechanised.

DE-GREASING AND ANODISING

The stage 2 finishing bay also incorporates equipment for continuous de-greasing and has a separate line for continuous anodising. The de-greasing plant is equipped with an edge-trimmer, and can handle strip up to 3 ft. finished width at 60 ft. per minute. Strip from this plant can be either re-coiled or passed through a cutting-up machine. The line consists of a cone decoiler pay-off stand, following which is an automatic traversing and spot-welding unit for joining consecutive coils. From this point the strip passes through driven pinch rolls, and edge-trimming stand, and thence into the trichlorethylene-vapour de-greasing plant. The equipment was manufactured by Imperial Chemical Industries, Limited, and is arranged with pressure sprays of clean trichlorethylene condensate at the delivery end, to supplement the vapour bath.

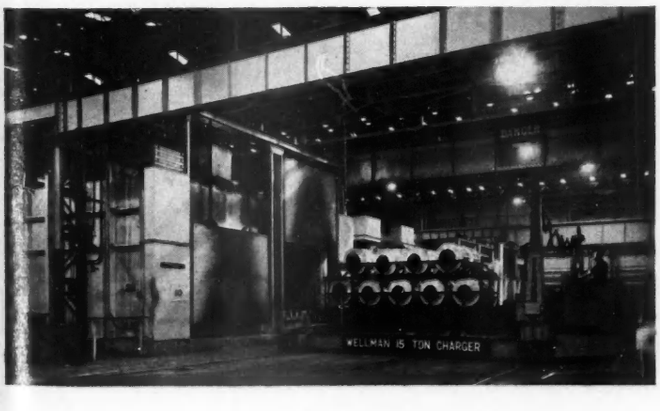


Fig. 9 The transporter-charger which serves the annealing furnaces in stage 2 of the works. It runs on an angled track and can receive coils from both parts of the works.

Water-cooled turrets at the entry and exit ends of the tank prevent carry-over of vapour. The complete internal framework carrying the strip-support rollers can be removed by overhead crane for ease of threading. The strip leaving the de-greasing plant is wrapped round a rubber-covered traction roll driven by a 7·5-h.p. direct-current motor, which controls the speed of the strip in its passage through the line. If coiled strip is required, the traction stand can be employed to create the necessary drag tension for coil winding on an expanding drum. Alternatively the stand can be used to create a slack loop in advance of a Farmer Norton flattening and cutting-up machine. This unit incorporates a roller leveller and flying shear, the shear being controlled by light beam and photo-electric cell.

Anodising of strip up to 24 in. wide is carried out in a recently installed continuous line, which consists of alkali de-greasing, anodising and washing tanks, infra-red drying equipment and a recoiler. The line is arranged in two tiers in order to conserve floor space, and re-coiling takes place adjacent to the pay-off stand. Automatic tack-welding equipment similar to that on the de-greasing line is provided, and since it is undesirable to stop the strip being processed, accumulator looping facilities are provided at each end of the processing plant. The line speed is about 10 ft. per minute, and the provision for looping is therefore not excessive.

THE ORIENT LINER "ORSOVA"

GENERAL DESIGN AND ACCOMMODATION

The liner Orsova, which has recently completed her first round voyage to Australia, is in various respects the most notable of the numerous important vessels – nine in the past 30 years – constructed at Barrow-in-Furness by Vickers-Armstrongs Limited for the Orient Steam Navigation Company. She is, in fact, the largest passenger liner yet built at Barrow and one of the largest built anywhere in the British Isles in the post-war years, being 722 ft. 9 in. in length overall and having a gross registered tonnage of 28,800. She is designed to carry 681 first-class passengers and 813 in the tourist class, as well as general and refrigerated cargo.

Other leading dimensions are: length between perpendiculars, 668 ft.; breadth moulded 90 ft. 6 in.; depth moulded to "E" deck, 50 ft.; and draught, 30 ft. 9 in. The shaft horse-power of the twin-screw propelling machinery is 42,500, corresponding to a service speed of 22½ knots. On trial, however, in the Bay of Arran, a mean speed of rather more than 26 knots was recorded, which makes her the fastest vessel on the Australian run. The best speed for two runs over the Arran "mile" was 26·068 knots.

There are nine decks, designated "A" to "J." The first-class accommodation is on decks "A" to "F" and the tourist on decks "C" to "H." The first-class cabins are all single-berth or two-berth with the exception of seven, which are fitted with three berths each, and 125 of the 377 first-class cabins are air-conditioned. Of the 813 tourist passengers, 278 will normally be in two-berth cabins, 15 in three-berth, 316 in four-berth, and 204 in six-berth cabins; but 20 of the six-berth cabins are so designed that they can be readily converted to form 40 two-berth cabins. An aerial view of the vessel is given in Fig. 1, below.

THE HULL

With the exception of the strength deck stringer angle and certain stiffeners in the deckhouses, the hull of the Orsova is entirely welded – a feature which probably contributed materially to the high speed attained on trial. During the past few years, the Barrow shipyard has been extensively re-organised to permit the full use of welding under the most efficient conditions and in the case of the Orsova units weighing as much as 50 tons were completely fabricated in the assembly shop adjoining the building berth, automatic welding being largely employed. To compensate for the loss of the flanges of the angles which would have been required in riveted construction to connect the floors to the shell plating, longitudinal stiffeners have been worked throughout the bottom structure. It will be recalled that the desirability of such stiffening was strongly emphasised in the discussion on Mr. J. M. Murray's paper, at the recent Spring Meeting of the Institution of Naval Architects, which was reported in ENGINEERING of May 7, on page 586, *ante*. It may be added that the Orsova was built under the survey of Lloyd's Register of Shipping, to their highest classification, and in accordance with the latest regulations of the Ministry of Transport, which have recently come into force.

In accordance with these rules, which embody the conclusions reached at the 1948 International Convention on Safety of Life at Sea, fire-screen bulkheads are provided in addition to the requisite transverse watertight bulkheads; and cross-levelling connections are fitted in way of the longitudinal watertight and oiltight bulkheads so that any list that may develop under damage conditions can be quickly corrected. All the internal staircases are constructed of steel and are surrounded by fire-screen bulkheads where necessary. In addition, there is a complete installation of Grinnell sprinklers, and an automatic fire-alarm system protects the whole of the accommodation for passengers and crew. In the holds and 'tweendecks there is a Pyrene fire-detecting system connected to the detector cabinet in the wheelhouse. Steam connections are provided for fire-extinguishing in the holds.

FIRST-CLASS PUBLIC ROOMS

The public rooms on "A" deck present a somewhat unusual combination of closed and open spaces. There is a restaurant and lounge, aft of the engine casing, and also a table-tennis room and the library; the restaurant, lounge and library are air-conditioned. In addition to these enclosed rooms, however, there are two sports arenas, each approximately square in plan, completely protected from cross winds by screens, and surrounded by raised decks for spectators. There is also a third space, over the restaurant, for quoit tennis. In view of the high speed of the ship, it is likely that these protected arenas will be very popular features.

Four separate stairways lead down to the public rooms on "B" deck. These comprise the main lounge, with its bar and service pantry, a main entrance hall, with galleries to port and starboard leading to the "Square," a space 60 ft. by 60 ft. which is enclosed by glazed screens and can be used for dancing or for cinema displays; and, right aft, the verandah bar, which overlooks the first-class swimming pool. At the extreme forward end of this deck is the children's playroom and open-air playing space, which is provided with a paddling pool and sand pit.

On "C" deck aft, adjoining the first-class swimming pool, is another bar, known as "The Tavern." The shops and some of the first-class cabins are also on this deck, but most are on "D" and "E" decks, with a few on "F" deck, forward of the dining saloon. A children's dining room and an auxiliary dining room which can be used for parties are also on "F" deck, all three dining rooms being air-conditioned. They can be approached either by a wide staircase from the main foyer, or by the two electric passenger lifts which connect all decks from "A" to "F." The main dining saloon seats 312 persons, and is subdivided by glazed screens, placed so as to avoid the objection which many passengers have to sitting at tables in a large open space. Concealed cornice lighting is used, with individual ceiling or bracket lights for the side tables. The chairs are upholstered in green leather, and the floor covering also is dark green. One of the first-class dining saloons is shown in Fig. 3.

The lounge has full-height windows along each side, and has doors and other woodwork of English ash; the furniture is of ash and beech. Concealed lighting is used here also, and in the galleries to port and starboard which lead aft to the verandah bar. These galleries are furnished with carpets, curtains, etc., of red and green, respectively, against elm-board panelling, "in a final humane determination" (to quote the official description *verbatim*) "to help those passengers who can never remember which is port and which is starboard." We fear, however, that the problem is not so easily solved; it will still be necessary to cope with

Fig. 1 The hull of the "Orsova," the fastest ship on the Australian run, is entirely welded. The funnel is designed to carry smuts clear of the open sports decks.

Fig. 2 This smoking lounge has full-height windows on both sides. The door and woodwork are of English ash and the walls and ceilings are painted.

the passenger who cannot remember which is red and which is green, even as the significant colours of port wine and crème de menthe.

At each side of the verandah bar are large bays raised slightly above deck level and separated from the central area by railings. The wide windows open out on to the verandah deck. Among the other rooms, mention has been made of the library, on "A" deck. This is rather larger than the corresponding room in the Oronsay, and is furnished in mahogany, with special lighting directed on to the bookshelves so that the titles of the books can be read easily. At the forward end is an altar recess, behind wide doors.

The chief responsibility for the interior decoration of the Orsova has been in the hands of Mr. E. Brian O'Rorke, A.R.A., F.R.I.B.A., the New Zealand architect, who was similarly responsible for the four previous vessels of the Orient Line fleet. He was assisted in the decoration of the tourist-class library and certain of the staterooms by Mr. John Wright, A.R.I.B.A.

TOURIST AND OTHER ACCOMMODATION

The promenade spaces for the tourist passengers are at the after end of "C," "D" and "E" decks. The swimming pool is on "C" deck, and on "D" deck is a "square," similar in general design to that for the first-class passengers, for dancing, cinema displays and other entertainments. It can be enclosed by sliding glazed screens, and has a raised dome in the centre. There is also a verandah bar on "D" deck. On "E" deck are the tourist library, shops, a children's playroom, and an open-air playing space, adjacent to it.

The dining saloon and lounge are on "F" deck; the saloon is air-conditioned. The all-electric galley, with its associated pantries, the bakery, sculleries, etc., is on the same deck, between the first-class and tourist dining saloons. The tourist saloon is the full width of the ship and 66 ft. long, and, like the first-class saloon, is provided with glazed screens to avoid giving the passengers the feeling that they are sitting in the middle of a room that is uncomfortably large. The room is finished almost entirely in plastics, and has a sound-absorbing ceiling. The chairs are of aluminium.

On the port side of "E" deck is a general hospital, arranged as a self-contained block, with four separate wards, a surgery, consulting room, bathroom, etc.; the whole of this space is air-conditioned. A separate isolation hospital is provided at the after end of the same deck.

A novel feature of the ship is that none of the cabins, for passengers or crew, is painted, all having wall coverings of plastic material. The same applies to the alleyways. The lighting of these alleyways in the first-class accommodation also presents features of novelty, the ceiling being used as a duct for the electrical and other cabin services, which are covered by a false ceiling of open slats through which the fluorescent-light fittings diffuse an even glow. The ceilings can be hinged down in sections for servicing. All the fittings for cabin lighting have been supplied by the General Electric Company.

OFFICERS' AND CREW'S QUARTERS

The cabins of the navigating officers are on the bridge decks and those of the engineers on "E" deck, where also is the engineers' messroom and sitting room. These rooms, and the cabins, are air-conditioned. All the officers are berthed in single cabins. The petty officers and leading hands are in either single or two-berth cabins, and many of these also are air-conditioned. Most of the ratings are accommodated on "F" and "G" decks.

The leading hands have their own messroom, which is also their recreation room, fixed screens separating the dining space from the sitting room. The ratings have a separate recreation room which is divided into two parts, one containing a bar, piano, etc., and the other reserved for reading, writing, and the quieter spare-time occupations. At its after end, it is divided from the main crew space by hinged screens, which can be opened in hot weather.

SPECIAL FEATURES

There are several special features about the design of the Orsova which, while not all of a technical nature in their relation to the construction or propulsion of the vessel, are definitely germane to her efficiency as a carrier of passengers and cargo. For example, the cruiser stern is of a fuller form above water than those of previous vessels, to give more space on the after decks. Instead of a number of separate baggage rooms, the whole of one hold is allocated to baggage and is subdivided into a number of separate rooms, fitted with racks, with access both by stairway and by a lift. A separate trunkway and hatch is provided for the loading and discharge of baggage – an innovation in the Orient Line. The storerooms, too, are arranged differently from previous practice, being all on one deck and laid out on each side of a central working alleyway.

The derrick posts represent another departure from previous practice, being of appreciably greater diameter to permit the topping lifts to be led down inside them. Also, one post only is fitted forward, on the centre line, in place of the customary port and starboard twin posts. There are separate 1-ton winches for topping the derricks, so that it is not necessary to run the much larger cargo winches for this purpose. Each hatch is served by 5-ton derricks and, in addition, there are four 10-ton derricks.

A new lighting arrangement has been adopted

Fig. 3 First-class dining saloon on "F" deck.

for the illuminated sign on the superstructure, displaying the ship's name. In earlier ships, the corresponding signs are flood-lighted, but in the Orsova the letters are in black on a backplate which is lighted by 5-ft. fluorescent fittings incorporated in the structure of the sign, so that the name appears to stand out in relief.

Lastly among these special features may be mentioned the funnel, the unique form of which, shown in Fig. 1, is quite distinctive and has excited a certain amount of controversy. In the previous Orsova, built 45 years ago by John Brown and Company at Clydebank, and in the rest of her class, the funnel proper projected slightly above the casing, the annular space between being covered by the usual "bonnet." In the new Orsova, however, the funnel rises some 15 ft. or more above the bonnet and the casing is tapered, being considerably longer and wider in plan at deck level than at the top. Aesthetically, the design is not notably attractive, but it is stated to be very effective in carrying smuts clear of the open sports decks, whatever the direction of the wind.

DECK AND NAVIGATING AUXILIARIES

For cargo-working there are four 5-ton winches and 16 of 3 tons lifting capacity, the former, which were supplied by Clarke, Chapman and Company, Limited, Gateshead-on-Tyne, being driven by 26-h.p. electric motors and fitted with remote control. The 3-ton winches, also electric, were constructed by Laurence Scott and Electromotors, Limited, Norwich, and are locally controlled. The seven 1-ton topping winches, previously mentioned, were also supplied by Clarke Chapman and Company and are driven by 5-h.p. motors, fitted with local control.

Of the 18 boat-hoisting winches which serve the Welin-Maclachlan gravity-type davits, all of which were made by Laurence Scott and Electromotors, Limited, 16 are rated at 20 h.p. each. The remaining two, for the emergency lifeboats, have 10-h.p. motors.

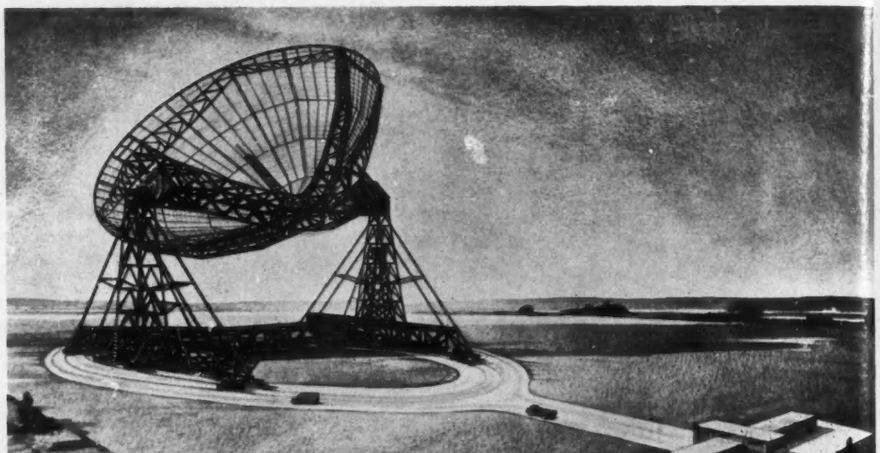
The electric windlass forward, which has dual warping drums, was supplied by Clarke, Chapman and Company, and is fitted with Ward-Leonard booster control. Two booster generators are provided, port and starboard, and these will generate current at 200 volts, positive or negative, which can be added to or substracted from the 220 volts on the driving motors, of 112-h.p. each, which are situated on "C" deck. On "E" deck aft there are two Clarke, Chapman warping capstans, each driven by a 64-h.p. motor.

The electro-hydraulic steering gear was supplied by Brown Brothers, Limited, Edinburgh, and is operated by two 60-h.p. motors, each driving a V.S.G. pump which can deliver to either two or four of the steering-gear cylinders. The motors have their own independent connections to the main switchboard, but with change-over switches in the hand-operated starters so that each motor can take current from either the port or the starboard main cable. There is also a 10-h.p. emergency steering motor, taking current from the emergency battery. In the event of failure of the main supply to both steering motors, this unit automatically cuts in and can maintain the steering gear in operation until the normal supply is restored. Provision is also made for Gyro-pilot control.

Messrs. Brown Brothers, Limited, have also supplied the equipment of Denny-Brown stabilisers, which can be controlled either from the bridge or from the stabiliser compartment. They take their current through an auxiliary switchboard in the same compartment. Each is operated by a main motor of 50-h.p.

Five electrically-operated vertical sliding watertight doors are fitted. These have been constructed by J. Stone and Company, Limited, Deptford, and can be supplied with current either from the main switchboard or the emergency board. They are controlled from the wheelhouse, where the source of the supply can be selected.

To be continued



Finished appearance of radio-telescope now under construction at Jodrell Bank.

THE RADIO-TELESCOPE OF MANCHESTER UNIVERSITY

UNDER CONSTRUCTION AT JODRELL BANK

The construction of the new radio-telescope for the University of Manchester has now been commenced at Jodrell Bank, about 25 miles south of Manchester, where the University's equipment and staff for the study of radio astronomy are segregated. As is now generally understood, radio astronomy is a relatively new science. It was only in 1931 that Jansky, an American scientist, discovered that radio waves were reaching the earth from outer space, but little notice was taken of his discovery at the time. At the end of the war, however, the radio and radar techniques, which had been highly developed for military purposes, were applied to the study of radio astronomy by scientists in this country and in Australia. The early radio-telescopes, using aerials of conventional types, served to confirm Jansky's results, but received the radiation in the form of a beam of some 10 to 20 deg. angular width; the resolution in these circumstances was so poor that it was not thought that much more information regarding the origin of the waves could be obtained by these means.

In 1948, however, simultaneous developments by Bolton and Stanley in Sydney, N.S.W., and by Ryle and Smith in Cambridge, led to the construction of a new type of radio-telescope which enabled the source of the radiation to be located with much greater accuracy. These telescopes, known as "interferometers," each employed two aerials separated by a distance of some hundreds of metres, the signals from each being connected to a common receiver. The reception pattern of a single aerial is in the form of a broad lobe, but that of two spaced aerials consists of a system of closely-packed lobes. As a telescope of the interferometer type is swept across the heavens the signal received remains steady as long as the source of radiation is large in width compared with the angular separation of the individual lobes. If, on the other hand, the radiation is emanating from a source which is small relatively to the separation of the lobes the signal received will vary through a series of maxima and minima. It is thus possible to locate the direction of the source with reasonable accuracy.

Using these radio interferometers, the scientists in Sydney were able to locate an intense source of radiation, with an angular diameter of less than 8 min. of arc, in the constellation Cygnus, and soon afterwards an even more intense source was discovered in Cassiopeia by the workers in Cambridge. A remarkable feature of this work was that although the sources of radiation could be located with considerable accuracy they could not at that time be identified with any visible object in these constellations. They were therefore regarded as invisible radio stars and the question immediately arose as to the number of such stars that may exist in the Galaxy in which the two constellations mentioned are comprised. About a hundred other radio stars have been discovered since, as the sensitivity of the radio equipment has been improved, but it is a plausible speculation that they are only the nearest and most intense of a very large number of such stars in the Galaxy. It seems reasonable to assume that, with the help of the new and improved equipment now being constructed, some at least of the diffuse radiation received from the Galaxy will be resolved into individual radio stars.

WORK AT JODRELL BANK

Professor A. C. B. Lovell, O.B.E., is in charge of the work at Jodrell Bank, and part of the existing equipment there is a fixed radio-telescope with a receiving system 220 ft. in diameter but only capable of receiving radiation in a single narrow beam. With this, radio waves from the Great Nebula in Andromeda, at a distance of 750,000 light years, have been detected, from which it is concluded that radio stars must exist in this nebula as well as in the Galaxy system and that the number of radio stars in each must be similar. The detection of radiation from the Andromeda nebula has been followed by the detection at Jodrell Bank and at Cambridge of

similar emissions from many other nebulæ. The angular diameters of some of the more intense sources have been measured and a few of them have been identified with objects that can be distinguished by means of ordinary optical telescopes. With the 200-in. reflector on Mount Palomar, for instance, the radio star in Cassiopeia has been found to agree in size and position with a very faint gaseous nebulosity just visible on photographs of the particular part of the constellation. Another striking discovery in radio astronomy was made in 1951 when scientists in Holland and America found a spectral line emission from hydrogen in the Galaxy on a wavelength of 21 cm. This, it is of interest to note, is the only known line frequency to be emitted in the radio-wave region. It is of the greatest importance because, by means of the Döppler principle, it is possible to establish the speed of recession of the hydrogen-gas clouds from which the radiation emanates. As recently as the spring of this year workers at Jodrell Bank have succeeded in measuring the distance of some of these radio stars, which is an outstanding achievement. The methods of radio astronomy have been and are being used in the study of the solar atmosphere and of the auroræ, meteors and the ionosphere, the latter being of great practical importance in connection with long-distance radio communications.

THE NEW RADIO-TELESCOPE

Such is a brief and very incomplete account of some of the problems of radio astronomy which the new radio-telescope now being constructed at Jodrell Bank will help to solve. They are sufficiently numerous to suggest that the telescope will be fully occupied for many years to come, even though its work can be carried on in daylight and will not be hampered by fog and conditions of bad visibility which frequently affect the work of visual and photographic telescopes, particularly in this country. The new telescope will have a parabolic reflector not greatly exceeding in diameter that of the existing fixed telescope at Jodrell Bank, which is 220 ft., as compared with 250 ft. Its great advantage will be that the reflector, or bowl as it is called, can be turned to any part of the celestial hemisphere and maintained automatically in the same direction as long as may be required. The depth of the bowl will be 62½ ft. and at its axis there will be an aerial tower 62½ ft. in height terminating at the focus of the parabola to receive the radiation. The bowl will be fixed to a lattice cross girder the ends of which will be carried in bearings on two towers 185 ft. in height. The towers will be built up on the ends of a horizontal structure of roughly H form in plan, resting on twelve bogies running on a circular rail track 310 ft. in diameter. Two of the bogies will be located at the ends of the central main cross girder and the others will be placed at the ends of outriggers to resist the overturning moments due to high winds.

A good idea of the appearance of the completed structure is given by the artist's sketch reproduced herewith, and it will be understood that the arrangement constitutes an alt-azimuth mounting in the telescope since the movement in azimuth can be obtained by turning the whole structure on the circular track while the altitude is adjusted by moving the bowl about the bearings of the supporting girder. The weight of the bowl and cross girder will be about 600 tons and the total weight carried by the bogies will be some 1,500 tons. The foundations, which are now completed, have been taken down to a depth of 90 ft. to reach the Kuyper marl and contain about 4,000 tons of concrete and some 700 tons of steel. The circular runway is also in position and the rails have been levelled to within ⅛ in. As the telescope is likely to be struck by lightning the tracks of the runway have been earthed at frequent intervals and arrangements have been made so that one or two of the bogies are always over one of the earth connections. Lifts and stairs to the top of the towers will be provided to give access to the laboratories there; another laboratory will be located in the bowl near the foot of the aerial mast. These laboratories will be screened to avoid electrical interference from the instruments. The station will have its own power house, this having been considered necessary to prevent interference effects from Grid or other cables near the telescope. The chief of the engineering problems, for which Messrs. Husband and Company, consulting engineers, of Sheffield, are responsible, will arise from high winds occurring during construction. Wind-tunnel experiments on a model, carried out at the National Physical Laboratory, have shown that the structure, when completed, will withstand any wind stresses to which it may be exposed, but special precautions will have to be taken against overturning while erection is in progress. The height to the top of the jib of the tallest crane to be used for erection will be 240 ft.

As will be obvious, there are many interesting and important details in connection with the design of this unique instrument, with some of which we hope to be able to deal at a later date. One point we may mention now is that, to increase the reflecting power of the bowl, its internal surface will be covered by a 1-in. square mesh of stout copper wire the weight of which will amount to about 30 tons. Another point of interest concerns the driving of the telescope to keep it directed continuously on to a particular star, irrespective of the rotation of the earth. The drive will be controlled by a clock, but as the equatorial mounting of such a large and heavy structure was considered to be impracticable, the telescope must be moved simultaneously both in azimuth and in altitude. This, we understand, will be effected automatically by electronic means.

The cost of the equipment is being defrayed jointly by the Department of Scientific and Industrial Research and the Nuffield Foundation.

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HIGH-TENSION OIL SWITCH

The General Electric Company, Limited, Magnet House, Kingsway, London, W.C.2, has recently developed a new design of oil switch, type OS4/2. It complies fully with British Draft Standard CR(ELE)2032. This switch can be supplied in extensible form with air-insulated, compound-insulated or oil-immersed bus-bars; or incorporated in non-extensible ring main units, as shown in the illustration. In the equipment illustrated and described the oil switches are mounted above the oil circuit breaker, within the space normally occupied by the bus-bars of a standard oil circuit breaker unit. Provision is made in the design for accommodating current transformers and essential metering.

The oil switch is designed for service on 3·3-kV, 6·6-kV or 11-kV systems and has a normal current carrying capacity up to and including 800 amperes. It is available in the following ratings: 150/250 MVA at 11 kV; 150 MVA at 6·6 kV; 75 MVA at 3·3 kV.

The moving contacts of the oil switch comprise spring-loaded twin blades which are held apart by a collar. A special feature of the design is that the direction of flow of the current is such that the magnetic forces assist in keeping the fixed and moving contacts together.

The switches are hand-operated from the front of the unit, the operating mechanism being designed to give a quick make-and-break action. Access to the operating handle is provided by a hinged front cover, the position of the switch being indicated through openings in the cover. Neon voltage indicators and test plugs can be supplied if required.

In this illustration, the high-tension oil switch is mounted directly above an oil circuit breaker instead of the bus-bars.

INTERLOCKS

Comprehensive systems of interlocking afford safety against mal-operation. For each oil switch the interlock takes the form of a slotted disc which must be rotated by hand, clockwise or anti-clockwise, until the position of the slot permits the desired operation to be performed. Any other movement of the switch is positively prevented.

Interlocking of the test plugs is accomplished by a moving shutter. Each moving shutter is actuated through a link mechanism designed so that the switch may be moved to "off" when the test plugs are in use but they cannot be withdrawn until the switch is returned to the "earth" position. A positive stop prevents the switch being closed in the "on" position while the test plugs are in use. A bracket welded on the interlock disc in conjunction with a fixed strip on the switch panel enables a simple and positive system of locking to be used to prevent unauthorised operation. In addition, the cover over the test-plug apertures and the hinged front door of the switch compartment can be locked. Fabricated steel cable boxes are provided and are designed to simplify connection, ample space being afforded between the bottom of the box and the floor for cable jointing.

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TWO NEW POWER STATIONS

The British Electricity Authority has received the consent of the Minister of Fuel and Power for the establishment of two new power stations, one at Erith, London, and the other at Elland, Yorkshire, to be known as the Belvedere and Elland power stations respectively.

The Belvedere station will have an installed capacity of 480,000 kW (640,000 h.p.), made up of eight 60,000-kW turbo-generators, while that of Elland will be 180,000 kW (240,000 h.p.), provided by three 60,000-kW sets. In both stations, each turbo-generator will be served by a boiler unit having an evaporative capacity of 550,000 lb. of steam an hour. The Elland station will also include two cooling towers each having a capacity of three million gallons of water an hour.

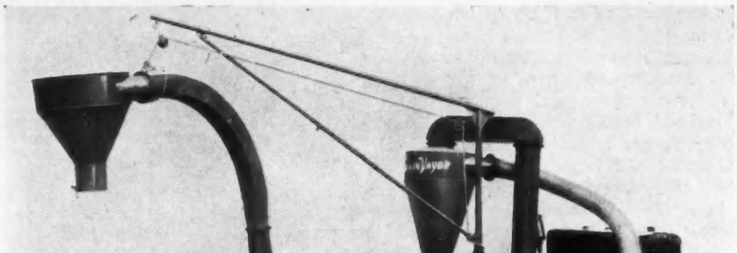


Fig. 7 Pneumatic conveyor for handling grain and similar materials with a capacity up to 1,000 bushels per hour.

Fig. 8 Stand-on fork truck with a moving-mast assembly giving a forward reach.

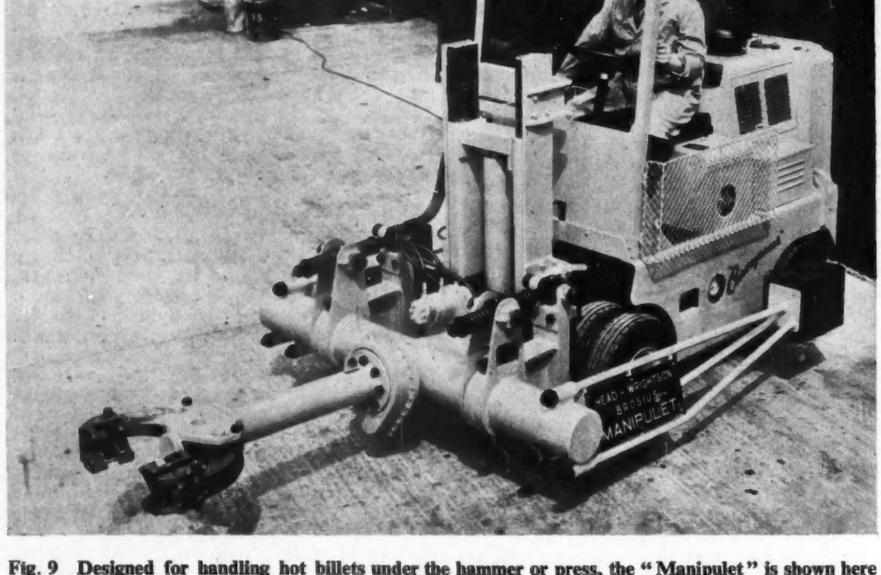


Fig. 9 Designed for handling hot billets under the hammer or press, the "Manipulet" is shown here fitted to a lift-truck.

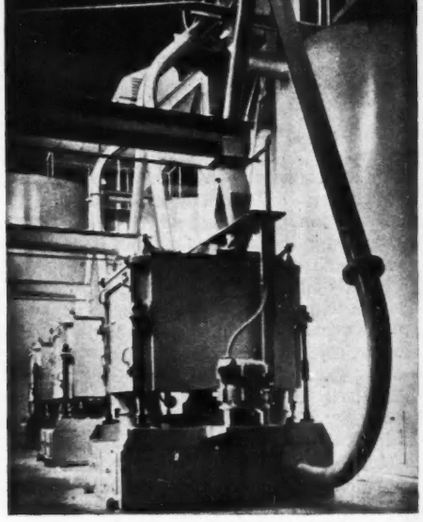
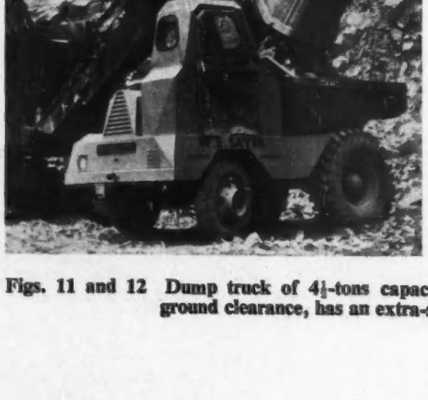


Fig. 10 Tubular conveying system with circular flights and neoprene rubber insulation.



Figs. 11 and 12 Dump truck of 4½-tons capacity. The unusual steering axle, giving exceptional ground clearance, has an extra-short track rod and centre steering.

Fig. 13 Lorry-mounted crane designed for easy maintenance.

MECHANICAL HANDLING EXHIBITION

Concluded from page 797

Our article on the fourth Mechanical Handling Exhibition, held at Olympia from June 9 to June 19, is continued below with descriptions of some more of the exhibits, which are illustrated on the opposite page.

MOBILE GRAIN CONVEYOR

The mobile grain conveyor shown in Fig. 7 was one of the main items of interest on the stand of Conveyors (Ready-Built), Limited, Cainscross, Gloucestershire. It is known as the "GrainVayor" and is being produced in this country under licence from the Myers Sherman Company, Streator, Illinois, U.S.A. With this machine grain and other similar materials can be quickly discharged from ships into storehouses or waiting vehicles. The material can be moved in any direction over a distance of 250 ft. and the machine can be operated by one man. With a 50-ft. conveying distance, 800 to 1,000 bushels per hour can be handled.

The complete machine is built on a pressed-steel chassis with four 6·50-in. by 16-in. pneumatic heavy-service tyres and disc wheels. Cable brakes operate on the two rear wheels and a hand parking-brake lever is fitted on the tow-bar. The grain suction and discharge pipes are all 8 in. in diameter. They are made from an abrasion-resisting steel and are fitted with "snap-in-place" connectors to enable the pipe length and direction to be easily changed.

The suction for lifting the grain is developed by a multi-stage turbine driven by a Lister FR6 Diesel engine, which develops 54 h.p. at 1,800 r.p.m. and has a fuel consumption of 2·8 gallons per hour. The material handled by-passes the turbine through the cyclone on the suction side and is transferred to the pressure side through a "Leak-pruf" rotary discharge-lock. This lock has been designed to give an air and vacuum seal which cannot be damaged by wire, nails or other tramp metal in the material being handled. A stationary model is also made with an electric-motor drive in place of the Diesel engine.

"STAND-ON" REACH TRUCK

The most recent development on the stand of Lansing Bagnall, Limited, Kingsclere-road, Basingstoke, Hampshire, was the SFR-225 "stand-on" reach fork truck.

It is similar to the straddle type of fork truck, but has the advantage of a mast assembly which can be moved forward hydraulically along the straddle-arms until the forks extend beyond the front wheels, as shown in Fig. 8. It can therefore be used as a normal fork truck and can pick up and deposit a load in the "reach" position. The load is then carried in a position of complete stability within the wheel base of the vehicle. The other feature of this truck is its excellent manœuvrability, for, although it has four wheels, it can turn in its own length.

The load-bearing chassis is coupled to the rider chassis by a horizontal pivot so providing articulated movement about a horizontal axis and improved stability when riding over uneven surfaces. One wheel is mounted at the end of each straddle-arm and the driving wheel, which is offset, is balanced by a twin articulated castor-wheel located beneath the driver's platform.

The mast assembly is moved to and fro by a mechanism consisting of a hydraulic jack operating a rack and pinion which in turn drives a sprocket and chain-linkage. The speed of travel is variable but is automatically slowed towards the end of the stroke. Control is by a single hand lever.

A dead-man's pedal is built in the rider platform. Steering is by a horizontally-mounted wheel on the left-hand side. Forward or reverse movement of the truck and lifting of the forks are controlled from a single hand lever adjacent to the wheel.

A variable-s[peed] shunt motor provides the driving power, w[hich] is transmitted to the wheels by spur gearing. A load of 2,500 lb. can be moved at 4½ m.p.h. With a pallet load 40-in. square the vehicle can be manœuvred in an aisle of about 60 in. wide. The service weight of the truck including the battery is 3,250 lb.

FORGING MANIPULATOR AND LIFT TRUCK

The Brosius "Manipulet," a forging manipulator designed to handle material being worked under the hammer or press, was shown on the stand of Conveyancer Fork Trucks, Limited, Liverpool-road, Warrington, Lancs. It is made by Head, Wrightson and Company, Limited, Thornaby-on-Tees. In Fig. 9, opposite, it is shown attached to a Conveyancer T.C.6 fork-lift truck.

Controlled by one man, the Manipulet does the work of the two, three and often four men normally required in forging manipulation crews, thereby speeding up the work by as much as 150 per cent.

The Manipulator is mounted on the elevating portion of the lift truck and is essentially a rotating peel and a work-holding head; the power to actuate these motions being taken direct from the truck's hydraulic system. The standard tongs can be replaced by a variety of special attachments including a peel-bar suitable for picking up the standard boxes used for charging melting furnaces. Two sizes of Manipulet are made, one for handling pieces weighing up to 500 lb. and the other for pieces up to 1,500 lb. These loads are based on a work-piece of 6 ft. in length. The tongs head can rotate continuously in either direction and a bladder-type accumulator is incorporated in the hydraulic circuit of the gripping cylinders to ensure that the pressure at the jaws remains constant.

The lift truck shown in the illustration has a fully-automatic drive, no clutch and requiring no gear changing. The operating controls are conveniently placed for the operator, and the principal motions of the Manipulet are forward and reverse floor travel, lifting and lowering of the peel, tilting of the peel both upwards and downwards, rotation of the tongs head in either direction and gripping the work-piece. The shock-absorption system of the Manipulet is arranged to counteract and counterbalance shocks from hammer blows on the work-piece. Hard-rubber stabilisers backed by heavy-duty helical springs are fitted to the front of the machine and counterweights are suspended along either side of the truck. Shock is absorbed by both these units, the counterweights also serving to move the centre of gravity of the load rearwards.

The Manipulet can be fitted to other types of lift truck provided they have solid rubber tyres and automatic clutchless transmission. Elsewhere in the exhibition the 1,500-lb. manipulator was shown fitted to a 10,000-lb. Coventry-Climax truck.

TUBULAR CONVEYOR SYSTEM

An interesting piece of conveying equipment known as the Fisholow-Hapman conveyor was shown on the stand of Fisher and Ludlow, Limited, Materials Handling Division, Bordesley Works, Birmingham, 12. It consists essentially of a steel tube through which is drawn a chain carrying flights. The chain is designed to follow through the pipe whatever direction it turns. Fig. 10, opposite, shows a typical application in a bakery at Montebello, California, U.S.A., where it is used for conveying flour.

The conveyor is dust-free as the pipe line can be completely sealed. Circular flights in the form of flat plates with neoprene-rubber skirts are attached to the chain. The neoprene skirt prevents metal-to-metal contact between the pipe wall, and the flights and also gives an improved scavenging action. This cleaning action means that a variety of materials can be passed through the pipe line in succession without contamination.

One of the important features of the design is the sealed pin used in the chain. The sealing is effected by neoprene-rubber washer or other suitable material between the individual links. This prevents abrasive materials entering the moving parts, and reduces wear. The maximum wear in the tube takes place at the lowest face on which the flights rest. When the inside of the tube begins to show signs of wear it can be rotated through 120 deg. to provide a fresh surface.

The drive for this system is usually taken from an electric motor driving a sprocket gear which fits into the links of the chain.

DUMPER TRUCK

To show clearly the design and construction of the dumper truck, which is illustrated in Fig. 11, the makers, Chaseside Engineering Company, Limited, Station Works, Hertford, displayed a number of the components and sub-assemblies. The fabricated steering axle, which is of unusual design, is shown in Fig. 12. This axle, made from sheet-steel sections welded together to form beams of box-section, has been developed to give exceptional ground clearance, an extra-short track rod, and centre steering, requiring the minimum of steering effort at the wheel.

The makers stress the fact that the vehicle is not an adaptation of other designs but has been developed and built entirely for use as a dumper. There are two models available, the D3 and D4. In one the driver faces the hopper and in the other the controls and seat are reversed so that the hopper is behind him. The standard power unit is the new Fordson Major Diesel or petrol engine or the Perkins P.6 Diesel can be fitted as an alternative. The heaped capacity of the hopper is 3·7 cub. yd. and the truck capacity 2·9 cub. yd. By weight the capacity is 4½ tons. For carrying rock a specially reinforced hopper can be fitted. The maximum speed in the fourth gear (top) is 20·7 m.p.h. and in first gear a gradient of about 1 in 4 can be negotiated.

The fabricated chassis incorporates a large-diameter torsion tube and longitudinal stiffeners. Heavy bumpers welded to each end provide additional bracing. A latchgear, operated from the driving position, controls the tipping action of the hopper. The final drive from the differential axle to the driving axle is by a heavy-duty chain, each wheel being independently connected. This arrangement allows shock to be taken by the rear axle without unnecessary loading of the differential.

The foot brake operates on all four wheels through a servo-assisted hydraulic mechanism, the hand brake operating on the load-carrying wheels only.

LORRY-MOUNTED CRANE

Sturdy construction, finger-tip control, ease of accessibility for maintenance and removal of the driving units, are said to be among the principal

features of the Staffa-10 lorry-mounted crane, which was on show for the first time. Two other features of interest were a light-alloy jib which can be used in place of the standard jib, and the direct air-pressure brake system which operates on all the wheels of this vehicle. Fig. 13, on page 828, shows the general appearance of the machine. The designers and manufacturers are Chamberlain Industries, Limited, Staffa Works, Leyton, London, E.10.

The chassis frame is fabricated from rolled-steel sections and heavy plate. The engine is a 9·6-litre A.E.C. six-cylinder Diesel. A gearbox of the remote-control type having five forward speeds and one reverse is fitted. The front axle is of the reversed Elliot type mounted on semi-elliptic leaf springs. Twin driving axles with twin wheels are mounted at the rear in an articulated bogie with solid beams. Four outriggers incorporating screw jacks are fitted to the chassis. When in use they extend to the corners of a rectangle measuring 18 ft. 6 in. by 11 ft. 6 in., thereby giving added stability during operation.

The upper frame consists of two parallel rolled-steel channels to which are welded steel A-frames. A Perkins L4 Diesel engine, developing 50·75 brake horse-power at 1,800 r.p.m., provides the operating power for the crane The engine is mounted on two light steel beams with trolley wheels attached to each end. The wheels run on two members of the upper frame which can be extended to facilitate withdrawal of the engine for inspection.

The hoist and luffing winches take their drive from two lay shafts. The shafts are each fitted with three multi-plate clutches, and mounted at the side of the main frame. Each clutch is hydraulically operated. The layshafts are chain driven in opposite directions. By engaging a clutch, the input shaft to a reduction gearbox is rotated in the desired direction. The design has been so arranged that one layshaft is driving when lifting, and when luffing the other layshaft is driving. Neither layshaft, therefore, transmits more than a small proportion of the full power of the engine.

The crane has been designed for a safe working load of 10 tons at 10 ft. radius. The hoisting speeds with a single-fall rope are 150 ft. per min., a two-fall 75 ft. per min. and a four-fall 37 ft. per min. The slewing speed is three revolutions per min., and luffing from minimum to maximum takes 90 seconds. With a 60-ft. jib, 1 ton 5 cwt. can be raised at a radius of 54 ft., providing the outriggers are in place.

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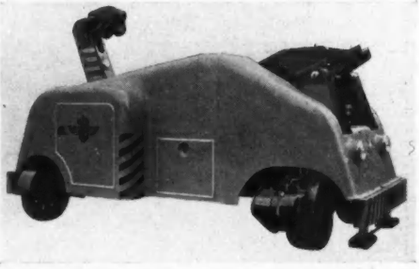
THE GAS GRID IN WALES

Some details of the progress of the North Wales and South Wales gas grids have been given by the Gas Council recently. Completion of the North Wales grid and of the eastern and western sections of the South Wales grid, and of the linking of the two sections, are among the chief projects to be undertaken by the Wales Gas Board in 1959-60. There still remain 74 miles of mains yet to be laid to complete the eastern section of the South Wales grid. When this is done and additional holder capacity becomes available, it will be possible to cease production at all coal gas-making stations except one in this section of the grid. Seven stations remain to be connected in the western section, and the 58 miles of mains scheduled to be laid during the period include the provision for linking the sections. To deal with increasing supplies of coke-oven gas, further purifying compressor plant and holder capacity will be needed at the Aberavon works. The possibility of a further extension of the South Wales grid from Carmarthen to Haverfordwest, to be known as the Pembrokeshire Grid, is also being considered by the Board.

The height of the jib of this Unicum crane, when fully extended, is 20 ft. All motions are hydraulically powered.



With the jib and mast collapsed, the overall height is 9·1 ft. The wheels can be turned through 90 deg. enabling the crane to traverse sideways.

HYDRAULICALLY-OPERATED TELESCOPIC MOBILE CRANE

4-ton Machine for Maintenance Work

For handling aero engines during aircraft overhauls, and for general cargo-loading, unloading, and transport, K.L.M. Royal Dutch Airlines have recently introduced an interesting and unusual mobile crane in their maintenance base at Schiphol airport, Amsterdam. The crane, which has a lifting capacity of 4,000 kg. (4 tons), was developed specially to K.L.M.'s requirement for manœuvrability in small spaces and a lift of 7 m. (22 ft.), combined with the ability to move freely below the maintenance docks, by the Unicum Company, Weert, Holland. The distributing agents for all Unicum products are Safe-Power Limited, Weert, Holland.

It will be observed from the illustrations that the necessary range of height adjustment is provided by a telescopic folding jib. All the motions, including forward and sideways traversing, are hydraulically operated, and are controlled by one man. Pressure is supplied by three pumps driven by a 60-h.p. six-cylinder Diesel engine. The mast is extended by a hydraulic ram, the stay being hydraulically locked.

The winch is driven by a hydraulic motor, and is smooth and precise in operation, an important point when using the crane for engine installation.

Forward traversing is effected by hydraulic motors driving the front wheels, coupled hydraulically so as to provide differential action without mechanical gearing. All four wheels are steered separately; they may be turned through 45 deg. and driven so that the crane rotates about its own axis, or, as may be seen from the illustrations, they may be turned through 90 deg. for sideways traversing. Jacks are provided to unload the front wheels for turning them when carrying a heavy load.

The leading particulars are as follow: lifting capacity, 4,000 kg. (4 tons); lifting height, 7 m. (22 ft.); turning radius, 2 m. (6·55 ft.); height of vehicle with jib folded, 2·77 m. (9·1 ft.); length, 4·6 m. (15·1 ft.); width (front), 1·95 m. (6·4 ft.); width (rear), 2·75 m. (9 ft.); maximum forward speed, 10 km. per hour (6·25 m.p.h.); weight of vehicle, 9,000 kg. (4,100 lb.).

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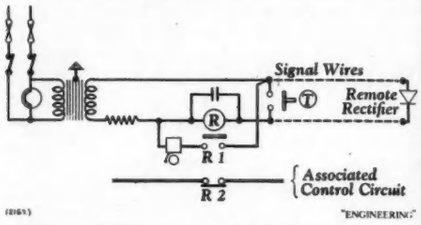
INTRINSICALLY SAFE SIGNAL SYSTEM

A signalling equipment manufactured by Hugh Wood and Company, Limited, Gateshead-on-Tyne, 11, conforms with the requirements for



Circuit diagram of the signalling system. It "fails to safety" under all conditions.

intrinsically safe equipment for use in dangerous atmospheres. A circuit diagram of the apparatus, which is contained in a flame-proof case, is shown above. It is normally supplied for 110 or 240-volt alternating-current supplies, but can be adapted for other voltages.

On the primary side of the circuit are two high-rupturing-capacity fuses, a two-pole switch and an indicating lamp. The secondary winding of the transformer is connected in series with a relay coil, R, and a half-wave rectifier forming a closed circuit. A test push button, T, is fitted on the case. Short circuiting the signal wires cuts out the rectifier and reduces the effective flux in the relay coil. The armature then drops out, contacts R1 close and ring the bell, while contacts R2 open and break the control circuit of the associated apparatus. Failure of the power supply or breakage of the signal wires has the same effect. Thus under all conditions the system will "fail to safety." Normal code signals can be transmitted by the system.

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NEW CHEMICAL PLANT IN SCOTLAND

British Petroleum Chemicals, Limited, are to erect a new chemical plant at their works at Grangemouth, Scotland. Part of the raw material for the new plant will be drawn from the adjacent refinery of Grangemouth Petroleum Refinery, Limited. The plant will produce alkylate, an industrial raw material of the type used in the manufacture of high-grade detergents. The new plant is expected to come into production during the latter half of 1955.

British Petroleum Chemicals, Limited, is jointly owned by Anglo-Iranian Oil Company, Limited, and the Distillers Company, Limited; Grangemouth Petroleum Refinery, Limited, is a wholly-owned subsidiary of Anglo-Iranian Oil Company, Limited.

FORTHCOMING EXHIBITIONS AND CONFERENCES

This list appears in the last issue of each month. Organisers are invited to send to the Editor particulars of forthcoming events.

YATES WELDING-SHOP PLANT. Mon., June 21, to Wed., July 14, at 336–338 High-road, Wembley, Middlesex. Private trade exhibition arranged by the Surrey Tool Development Co., Ltd., 156–158 Dalston-lane, London, E.8. WILlesden 2434.

ROYAL SHOW. Tues., July 6, to Fri., July 9, at Windsor. Organised by the Royal Agricultural Society of England, 16 Bedford-square, London, W.C.1. Tel. MUSeum 5905.

"PRODUCTION FOR PLENTY" EXHIBITION AND CONFERENCE. Wed., July 7, to Wed., July 14, at Olympia, London, W.14. Sponsored by the Institution of Production Engineers, 36 Portman-square, London, W.1. Tel. WELbeck 6813. See also our issue of February 12, page 194.

NON-DESTRUCTIVE TESTING CONFERENCE. Wed., July 7, to Sat., July 10, at the Chancellor's Hall, University of Birmingham. Organised by the Non-Destructive Testing Group, Institute of Physics, 47 Belgrave-square, London, S.W.1. Tel. SLOane 9806. See also our issue of April 23, page 515.

INDUSTRIAL ELECTRONICS CONVENTION. Thurs., July 8, to Mon., July 12, at Christ Church, University of Oxford. Organised by the British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. Tel. MUSeum 1901. See also our issue of March 26, page 413.

LAUNDRY, DRY CLEANING AND ALLIED TRADES EXHIBITION. Thurs., July 8, to Sat., July 17, at Olympia, London, W.14. Organisers: F. W. Bridges and Sons, Ltd., Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 0568.

INDUSTRIAL USES OF ELECTRONICS. Thurs., July 8, to Mon., July 12, at the University of Oxford. Convention arranged by the British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. Tel. MUSeum 1901. See also our issue of June 4, page 710.

HUMAN RELATIONS AND SIZE OF INDUSTRY CONFERENCE. Fri., July 9, to Sun., July 11, at Girton College, Cambridge. Organised by the Industrial Co-partnership Association, 36, Victoria-street, London, S.W.1. Tel. ABBey 3342.

GREAT YORKSHIRE AGRICULTURAL SHOW. Tues., July 13, to Thurs., July 15, at Harrogate. Organised by the Yorkshire Agricultural Society, Great Yorkshire Showyard, Hookstone-drive, Harrogate. Tel. Harrogate 6014.

CONFERENCE ON DEFECTS IN CRYSTALLINE SOLIDS. Tues., July 13, to Sat., July 17, at the H. H. Wills Physical Laboratory, Royal Fort, Bristol, 8. Organised in conjunction with the Institute of Physics. Further particulars may be obtained from the secretary of the Laboratory; or the secretary, Institute of Physics, 47 Belgrave-square, London, S.W.1. Tel. SLOane 9806.

RADIOISOTOPE CONFERENCE.—Mon., July 19, to Sat., July 24, at Oxford. Arranged by the Atomic Energy Research Establishment, Harwell. Further details obtainable from the conference secretary, A.E.R.E., Harwell, Didcot, Berkshire. Tel. Abingdon 620.

ROYAL WELSH AGRICULTURAL SHOW. Wed., July 21, to Fri., July 23, at Machynlleth. Organised by the Royal Welsh Agricultural Society, Queen's-road, Aberystwyth. Tel. Aberystwyth 7551.

WORLD POWER CONFERENCE, SECTIONAL MEETING. Sun., July 25, to Tues., Aug. 10, at Rio de Janeiro, Brazil. Applications should be sent to the secretary, British National Committee, World Power Conference, 201-2 Grand Buildings, Trafalgar-square, London, W.C.2. Tel. WHItehall 3966.

HARROGATE: THE RIDINGS INTERNATIONAL FAIR. Sat., July 31, to Sat., Aug. 14. Organised by Regional Exhibitions, Ltd., Salfords, Surrey. Tel. Horley 64.

DANISH INDUSTRIES FAIR. Thurs., Aug. 5, to Sun., Aug. 15, at Fredericia, Denmark. Organised by Dansk Kobestaevne Fredericia, Jutland, Denmark.

INTERNATIONAL MODEL ENGINEER EXHIBITION. Wed., Aug. 18, to Sat., Aug. 28, at the New Horticultural Hall, Greycoat-street, London, S.W.1. Apply to Mr. G. Withers, 19 and 20 Noel-street, London, W.1. Tel. GERrard 8811.

21ST NATIONAL RADIO AND TELEVISION EXHIBITION. Wed., Aug. 25, to Sat., Sept. 4, at Earl's Court, London, S.W.5. Apply to the Radio Industry Council, 59 Russell-square, London, W.1. Tel. MUSeum 6901.

ST. ERIK'S INTERNATIONAL FAIR. Sat., Aug. 28, to Sun., Sept. 12, at Stockholm. *Agents:* Thirza West Publicity Ltd., 141 New Bond-street, London, W.1. Tel. MAYfair 3701.

FIFTH SYMPOSIUM ON FLAME AND COMBUSTION. Mon., Aug. 30, to Fri., Sept. 3, at the University, Pittsburgh. Apply to the chairman of the organising committee, Dr. B. Lewis, 200 Alcoa Building, Pittsburgh 19, U.S.A.

BRITISH ASSOCIATION MEETING. Wed., Sept. 1, to Wed., Sept. 8, at Oxford. Apply to the secretaries, British Association for the Advancement of Science, Burlington House, Piccadilly, London, W.1. Tel. REGent 2109. See also our issue of April 23, page 518.

SCOTTISH INDUSTRIES EXHIBITION. Thurs., Sept. 2, to Sat., Sept. 18, at the Kelvin Hall, Glasgow. Apply to the offices of the exhibition, 16 Woodside-terrace, Glasgow, C.3. Tel. Douglas 8811. See also our issue of June 11, page 739.

NATIONAL HANDICRAFTS AND HOBBIES EXHIBITION. Thurs., Sept. 2, to Sat., Sept. 11, at the Central Hall, Westminster, London, S.W.1. Organised by Henderson Exhibitions, Ltd., 74 Holland Park, London, W.11. Tel. PARk 7360.

STRASBOURG INTERNATIONAL INDUSTRIAL FAIR. Sat., Sept. 4, to Sun., Sept. 19. *Agents:* Auger and Turner Group, Ltd., 40 Gerrard-street, London, W.1. Tel. GERrard 6671.

LEIPZIG INTERNATIONAL TRADE FAIR. Sun., Sept. 5, to Wed., Sept. 15. *Agents:* Willoughby and Young, 6A Smith-street, London, S.W.3. Tel. SLOane 1594.

COLOGNE INTERNATIONAL AUTUMN FAIR. Sun., Sept. 5, to Tues., Sept. 7, for household goods and hardware. Sun., Sept. 12, to Tues., Sept. 14, for textiles, leather and fancy goods. Sun., Sept. 12, to Wed., Sept. 15, for foreign groups' collective exhibits. *Agent:* Mr. Neven du Mont, 123 Pall Mall, London, S.W.1. Tel. WHItehall 8211.

FRANKFURT INTERNATIONAL AUTUMN FAIR. Sun., Sept. 5, to Thurs., Sept. 9. *Agents:* Lep Transport Ltd., Sunlight Wharf, Upper Thames-street, London, E.C.4. Tel.: CENtral 5050.

FLYING DISPLAY AND EXHIBITION, FARNBOROUGH. Mon., Sept. 6, to Sun., Sept. 12, at Farnborough, Hampshire. Open to the public on Fri., Sat. and Sun., Sept. 10, 11 and 12 only. Organised by the Society of British Aircraft Constructors, Ltd., 32 Savile-row, London, W.1. Tel. REGent 5215.

ROYAL NETHERLANDS FAIR. Tues., Sept. 7, to Thurs., Sept. 16, at Utrecht, Holland. *Agent:* Mr. W. Friedhoff, 10 Gloucester-place, London, W.1. Tel. WELbeck 9971.

WELSH INDUSTRIES FAIR. Wed., Sept. 8, to Sat., Sept. 18, at Sophia Gardens Pavilion, Cardiff. Organised by the National Industrial Development Council of Wales and Monmouthshire Ltd., 17 Windsor-place, Cardiff. Tel. Cardiff 23049.

WAVE RESEARCH CONGRESS. Wed., Sept. 8, to Sat., Sept. 11, at Grenoble, France. Held under the auspices of the Council on Wave Research of the Engineering Foundation, University of California. Communications to the Coast Engineering Congress, Ecole Nationale Supérieure d'Electrotechnique et d'Hydraulique, 44-46 Avenue Félix Viallet, Grenoble.

INTERNATIONAL HANDICRAFTS, HOME CRAFTS AND HOBBIES EXHIBITION. Thurs., Sept. 9, to Thurs., Sept. 23, at Olympia, London, W.14. Exhibition office: 24 Store-street, London, W.C.1. Tel. MUSeum 9792.

OPEN-HEARTH FURNACE FLAMES. Fri., Sept. 10, at 39 Elmbank-crescent, Glasgow, C.2. All-day conference organised by the West of Scotland Iron and Steel Institute. Applications to be addressed to the Institute at the above address. Tel. Central 5181. See also our issue of June 4, page 710.

WEST COUNTRY INTERNATIONAL FAIR. Sat., Sept. 11, to Sat., Sept. 25, at Bristol. Organised by Regional Exhibitions, Ltd., Salfords, Surrey. Tel. Horley 64.

FIRST INSTRUMENT CONGRESS AND EXPOSITION. Mon., Sept. 13, to Fri., Sept. 24, in the Commercial Museum and Conference Hall, Philadelphia. Sponsored by the Instrument Society of America. Apply to the manager, Mr. Richard Rimbach, 845 Ridge-avenue, Pittsburgh 12, Pennsylvania, U.S.A.

PUBLIC LIGHTING CONFERENCE AND EXHIBITION. Tues., Sept. 14, to Fri., Sept. 17, at the Pavilion, Devonshire Park, Eastbourne. Organised by the Association of Public Lighting Engineers, 22 Surrey-street, London, W.C.2. Tel. TEMple Bar 9607.

4TH EUROPEAN MACHINE TOOL EXHIBITION. Tues., Sept. 14, to Thurs, Sept. 23. Apply to the Machine Tool Trades Association, Victoria House, Southampton-row, London, W.C.1. Tel. HOLborn 4667.

SUSSEX INDUSTRIES FAIR. Wed., Sept. 15, to Sat., Sept. 25, at the Corn Exchange, Brighton. Organised by the Federation of Sussex Industries, Ltd., 32 Duke-street, Brighton 1. Tel. Brighton 26189.

INTERNATIONAL TECHNICAL AND INDUSTRIAL EXHIBITION. Sat., Sept. 18, to Sun., Oct. 3, at Charleroi, Belgium. Offices: Hotel de Ville, Charleroi. *Agents:* Auger and Turner Group Ltd., 40 Gerrard-street, London, W.1. Tel. GERrard 6671.

INTERNATIONAL COMMERCIAL MOTOR TRANSPORT EXHIBITION. Fri., Sept. 24, to Sat., Oct. 2, at Earl's Court, London, S.W.5. Organised by the Society of Motor Manufacturers and Traders, Ltd., 148 Piccadilly, London, W.1. Tel. GROsvenor 4040.

ASLIB ANNUAL CONFERENCE. Fri., Sept. 24, to Mon., Sept. 27, at Church House, London, S.W.1. Further information obtainable from the secretary, Aslib, 4 Palace-gate, London, W.8. Tel. WEStern 6321.

BUSINESS EFFICIENCY EXHIBITION, MANCHESTER. Mon., Sept. 27, to Sat., Oct. 2, at the City Hall, Manchester. Organised by the Office Appliance and Business Equipment Trades Association, 11-13 Dowgate-hill, London, E.C.4. Tel. CENtral 7771.

ENGINEERING INDUSTRIES ASSOCIATION: LONDON REGIONAL DISPLAY. Tues., Oct. 12, to Thurs., Oct. 14, at the Royal Horticultural Society's New Hall, Greycoat-street, London, S.W.1. Apply to the secretary of the Association, 9 Seymour-street, Portman-square, London, W.1. Tel. WELbeck 2241.

CATALOGUE EXHIBITION. Tues., Oct. 12, to Sat., Oct. 23, at the British Institute of Management, 2 Hill-street, London, W.1. Organised by the British Federation of Master Printers, 11 Bedford-row, London, W.C.10. Tel. CHAncery 6904.

BUILDING TRADES EXHIBITION. Tues., Oct. 19, to Sat., Oct. 30. Apply to Provincial Exhibitions, Ltd., City Hall, Deansgate, Manchester, 3. Tel. Deansgate 6363.

INTERNATIONAL MOTOR EXHIBITION. Wed., Oct. 20, to Sat., Oct. 30, at Earl's Court, London, S.W.5. Organised by the Society of Motor Manufacturers and Traders, Ltd., 148 Piccadilly, London, W.1. Tel. GROsvenor 4040.

BRITISH TRADE FAIR, BAGHDAD. Mon., Oct. 25, to Mon., Nov. 8, at Baghdad, Iraq. Organised, at the invitation of H.M. Government, by British Overseas Fairs, Ltd., 21 Tothill-street, London, S.W.1. Tel. WHItehall 6711. See also our issue of January 29, page 135.

ELECTRICAL AND RADIO EXPOSITION. In October, at Melbourne, Australia. Organised by the Electrical and Radio Federation (Victoria), Dominion Chambers, 59 William-street, Melbourne, C.1.

SAFETY IN CHEMICAL WORKS. Fri., Nov. 5, to Sun., Nov. 7, at Harrogate. Conference organised by the Association of British Chemical Manufacturers, 86 Strand, London, W.C.2. Tel. COVent Garden 2363.

CYCLE AND MOTOR CYCLE SHOW. Sat., Nov. 13, to Sat., Nov. 20, at Earl's Court, London, S.W.5. Organised by the British Cycle and Motor Cycle Manufacturers' and Traders' Union, Ltd., The Towers, Warwick-road, Coventry. Tel. Coventry 62511.

PUBLIC WORKS AND MUNICIPAL SERVICES CONGRESS AND EXHIBITION. Mon., Nov. 15, to Sat., Nov. 20, at Olympia, London, W.14. Organised by The Municipal Agency, Ltd., 70 Victoria-street, London, S.W.1. Tel. VICtoria 9132.

X-RAY APPARATUS EXHIBITION. Tues., Nov. 23, to Fri., Nov. 26, at the Royal Horticultural Hall, Vincent-square, London, S.W.1. Organised in conjunction with the congress of the British Institute of Radiology, 32 Welbeck-street, London, W.1. Apply to Mr. A. Beetlestone, Mullard, Ltd., New-road, Mitcham Junction, Surrey. Tel. Mitcham 2071.

INTERNATIONAL "AUTOMATION" EXHIBITION. Week commencing Mon., Nov. 29, at 242nd Coast Artillery Armory, 14th-street off Sixth-avenue, New York. Apply to Mr. Richard Rimbach, 845 Ridge-avenue, Pittsburgh 12, Pennsylvania, U.S.A.

POWDER METALLURGY SYMPOSIUM AND EXHIBITION. Wed. and Thurs., Dec. 1 and 2, at Church House, Great Smith-street, London, S.W.1. Organised by the Iron and Steel Institute and the Institute of Metals. Apply to the secretary, Iron and Steel Institute, 4 Grosvenor-gardens, London, S.W.1. Tel. SLOane 0061. See also our issue of April 23, page 518.

CHEMICAL AND PLASTICS EXHIBITION. Fri., Dec. 3, to Sun., Dec. 12, at Porte de Versailles, Paris. Offices: 28 Rue Saint-Dominique, Paris, 7e. *Agents:* Butler's Advertising Service, 22 St. Giles High-street, London, W.C.2. Tel. TEMple Bar 5905.

Labour Notes

EQUAL PAY FOR INDUSTRIAL EMPLOYEES

Pressure is expected to be brought to bear on the Government, in the near future, to provide opportunities for discussions on the question of granting equal pay to women operatives in the Government's industrial establishments. The principle of equal pay for women employees in the non-industrial Civil Service has already been accepted by the Government.

In a statement made at the close of a meeting of the executive council of the Transport and General Workers' Union on June 18, Mr. Arthur Deakin, the union's general secretary, said that the T.G.W.U. was definitely in favour of such a policy and anxious for its implementation.

There was grave concern, Mr. Deakin stated, at the failure of the trade-union side of the joint industrial councils for the Admiralty and other Government departments to secure a meeting with the Chancellor of the Exchequer to discuss the matter. For this reason, the subject would be raised at an early meeting of the Trades Union Congress General Council, and it was hoped that this action would result in the Chancellor being asked to concede the same treatment to women industrial operatives in the Government's employ, as to women in other branches of the Civil Service.

ABRUPT REJECTION OF WAGE CLAIMS RESENTED

On the same occasion, Mr. Deakin complained about the action of wage boards which, allegedly, reject workpeople's claims too readily. He said that great resentment was felt that agricultural employees had been singled out for an " abrupt " refusal of their demands.

The manner in which that wage application had been dealt with by the Agricultural Wages Board had been a source of much annoyance to the Transport and General Workers' Union. Mr. Deakin also criticised the case in which the wage claims of certain grades in the Post Office were considered by the Civil Service Arbitration Tribunal.

In that instance, the chairman of the Tribunal announced, before the Union of Post Office Workers had presented its verbal case for a wage increase, that the union's written claim provided no basis on which the wage scales being sought could be evaluated. The general secretary of the union, it may be recalled, immediately withdrew the claim. Subsequently, a re-hearing took place under a different chairman.

With respect to the rejection of the agricultural employees' claims, Mr. Deakin stated that the T.G.W.U. and the National Union of Agricultural Workers have asked the Minister of Labour and the Minister of Agriculture to receive a deputation to discuss the matter.

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NOTICES OF MEETINGS

Institute of Metals

LONDON
" The Brittle Fracture of Metals: Some New Developments," by Professor E. Orowan. Wed., June 30, 5 p.m.

Institution of Mining Engineers

SHEFFIELD
Summer Meeting, Wed., Thurs. and Fri., July 7, 8 and 9. " Recent Research in Mining Subsidence," by C. Beevers and K. Wardell. University of Sheffield, morning session, Wed., July 7. " Machine Mining: Concentration in Space and Time," by A. Scott and W. M. Noble. University of Sheffield, afternoon session, Wed., July 7. Institution dinner, Cutlers' Hall, Sheffield, Thurs., July 8. Various visits and excursions.

Royal Meteorological Society

GODALMING, SURREY
Summer Meeting. National Institute of Oceanography, Wormley, near Godalming, Surrey. Wed., July 7.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

Institute of Metals, 4 Grosvenor-gardens, London, S.W.1. (SLOane 6233.)
Institution of Mining Engineers, Salisbury House, Finsbury-circus, London, E.C.2. (MONarch 9758.)
Royal Meteorological Society, 49 Cromwell-road, South Kensington, London, S.W.7. (KENsington 0730.)

DRAUGHTSMEN RECEIVE SALARY INCREASE

As the result of further negotiations with the Association of Engineering and Shipbuilding Draughtsmen, the Engineering and Allied Employers' National Federation agreed on June 16 to recommend affiliated firms to grant an increase of 10*s.* 6*d.* a week to engineering draughtsmen, aged 25 or over, in their employ.

The agreement provides that men aged 23 and 24 should receive an increase of 9*s.* 6*d.* a week, and those aged 21 and 22 an advance of 8*s.* 6*d.* a week. It is recommended that women tracers aged 19 and above should be given 7*s.* a week more.

The increases are to be ante-dated to May 10 last and it is expected that, in all, some 50,000 employees will benefit.

BOILERMAKERS DEMAND SUBSTANTIAL WAGE INCREASE

Among the many items on the agenda of the annual conference of the United Society of Boilermakers, Shipbuilders and Structural Workers, at Blackpool, last week, were a number of motions relating to wage questions.

At a session dealing with these matters, on June 16, unanimous approval was given to an emergency resolution which stated that the conference demanded that an early application should be made to the employers' organisations for a substantial increase for all members of the union.

The resolution stated that members of the conference expressed their appreciation of the efforts of their executive council in pursuing the union's recent claim for an all-round increase of 15 per cent. At the same time, it was affirmed, the conference was much concerned at the steady deterioration which was taking place in the living standards of members of the union, and, conversely, at the high profits which were being made in industry. The conference was of the opinion that the reply given by the employers, to the evidence submitted by the union's representatives in support of the recent wage claim, was, in effect, no answer at all.

In its original form, the resolution asked for a definite wage increase of 10 per cent. Later, an amendment was moved calling for a substantial increase and demanding that this should be retrospective.

After a brief discussion, it was announced that the proposers of the original motion and the amendment had agreed to the resolution being put to the meeting in the form in which it was finally approved.

DECLINE IN COST-OF-LIVING INDEX

There was a fall of one point in the level of the interim index of retail prices during the period between April 13 and May 18, according to an announcement by the Ministry of Labour on June 18. The index figure stood at 141 on May 18, compared with 142 on April 13 and 141 on March 16. The figure in mid-April was the highest so far recorded. In mid-May last year, the index figure was 140.

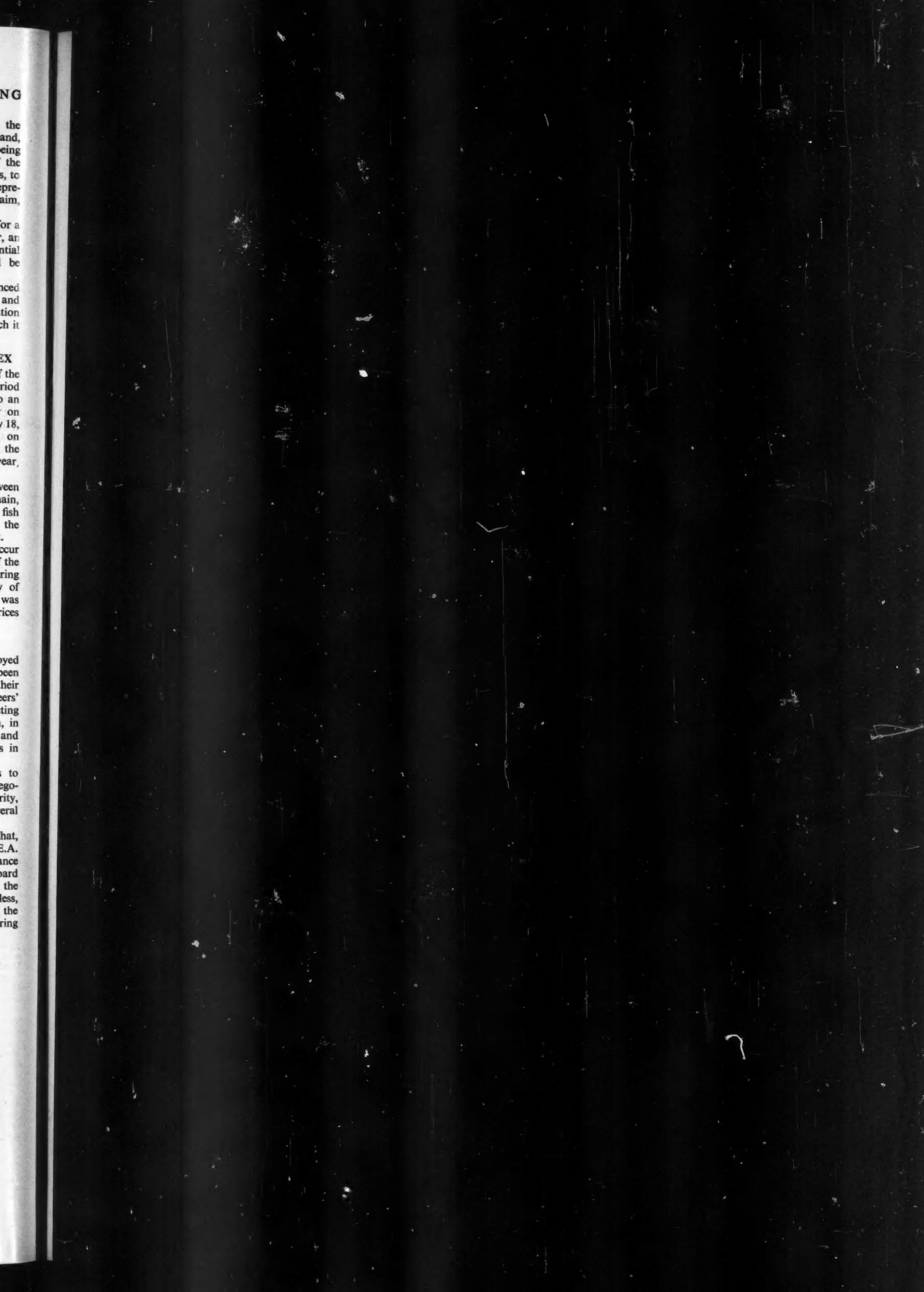
The decline in the level of the index between April 13 and May 18 last was due, in the main, to reductions in the average prices of milk, fish and coal. These were partly offset by the higher prices of tea, potatoes and fresh fruit.

The index measures the changes which occur from month to month in the average level of the retail prices of commodities and services entering into the expenditure of the great majority of households in the United Kingdom. It was introduced on June 17, 1947; the level of prices on that date being taken as 100.

STATUS OF POWER ENGINEERS

For some time past, technical staffs employed in the electricity-supply industry have been seeking to obtain a higher status, through their trade union, the Electrical Power Engineers' Association. The men are desirous of effecting a substantial improvement in their position, in relation to other employees in the industry, and are hoping to obtain considerable advances in their remuneration.

Little or no progress, however, appears to have been made by the Association in its negotiations with the British Electricity Authority, although these have extended over several months.

The Association announced on June 16 that, owing to the absence of a settlement, the B.E.A. had been given six months' notice, in accordance with the terms of the National Joint Board Agreement, to terminate that agreement and the salary schedules related to it. Nevertheless, there is every hope that negotiations between the union and the B.E.A. will be continued during the ensuing months.

END OF THE 177th VOLUME